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ABSTRACT

This production systems guide provides teachers with learning activities for secondary students. Introductory materials include an instructional planning outline and worksheet, an outline of essential elements, domains and objectives, a course description, and a content outline. The guide contains 30 modules on the following topics: production materials; production processes; production organization; the enterprise system; material testing; structure classification; company management--construction and manufacturing; product development; simulation of automation; space production systems; human-powered vehicle; the tower of pasta; materials assembly; using robots in industry; consumer goods; name that material; types and grades of production materials; calculating quantities and costs of production materials; basic robotics; introduction to problem solving; advanced problem solving--teamwork; rafter lengths for roof construction; concrete design and construction; a structural framing model; basic blueprint reading--architectural plans; designing and building an aluminum can crusher; building a home recycling center; exploring space-based construction; foundation structures; and structures and forces of nature. Each module includes an instructor's resource sheet and the student laboratory activity. Each instructor's resource sheet may include the following elements: module number; activity topic; estimated time; essential elements; objectives; activity summary; teaching tips; instructional strategy; equipment/supplies; evaluation key; and support materials. Each student activity may include the following elements: module number; activity topic; activity overview; objectives; vocabulary/concepts reinforced; equipment/supplies; introduction; procedure; evaluation; and support materials. (NLA)

Production Systems

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Production Systems

Laboratory Activities

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Organization of the Laboratory Activity Materials

The major portion of the guide is the compilation of laboratory activity modules. The laboratory activity modules were developed, tested, and reviewed by technology teachers, supervisors, and teacher educators.

Each module includes (1) an instructor's resource sheet and (2) the student laboratory activity.

Each instructor's resource sheet includes the following elements where appropriate:

- Instructor's resource sheet module number
- Activity topic
- Estimated time
- Essential Elements (common and specific)
- TAAS Objectives
- Activity Summary
- Teaching Tips
- Instructional Strategy
- Equipment/Supplies
- Evaluation Key
- Support Materials

Each student activity includes the following elements where appropriate:

- Student activity module number
- Activity topic
- Activity overview
- Objectives
- Vocabulary/Concepts Reinforced
- Equipment/Supplies
- Introduction (to the activity)
- Procedure (step-by-step)
- Evaluation
- Support Materials

Using the Laboratory Activity Materials

Intended Audience: The material in this guide is designed for use by technology teachers and students in grades nine through twelve. Many of the modules, however, would also be appropriate and recommended for use by junior high/middle school technology programs.

Length of Time for the Materials: The topic of study has been developed to provide materials for 18 to 36 weeks of study. Each module includes a suggested time frame for completion of the activity/module.

Benefits for Teachers and Students: The materials included in this guide were developed to assist technology teachers in planning, organizing, teaching, implementing, and evaluating a technology-based instructional program. The broad exposure students will receive by being involved in the laboratory activities in this guide will enhance their total educational program experience including their problem-solving skills, creative thinking skills, and social interaction skills, as well as communication, computation, and technical skills.

Flexibility of the Materials: This guide, like other curriculum materials, does not attempt to encompass all situations. Therefore, teachers should supplement the guide with other appropriate ideas, information, and activities as needed in their particular programs.

A key feature in this guide is flexibility. The material may be used in the context of a large class/group approach, a small group approach, where appropriate, and, in many of the modules, an individualized approach. In some of the modules, a combination of all three approaches might be incorporated.

Modules should be selected by teachers in the order that they choose, and teachers are encouraged to expand or condense the student laboratory activity to meet the needs of addressing essential elements and the time frame designated to cover the topic. Teachers may also need to make substitutions in the use of each modules, depending on the equipment, resources, and/or reference materials available to them.

Essential Elements/TAAS Objectives: Essential elements and TAAS objectives for reading, writing, and mathematics have been identified in each module (where appropriate). As used in this guide, essential element statements represent skills, knowledge, and/or attitudes that imply the ability or intelligence to accomplish an idea, problem, task, job, etc. Essential element statements will assist the teacher in clearly formulating the scope and sequence of the course of study and the purpose and processes for student learning.

Instructional Planning: An instructional planning outline and worksheet are included in the guide for teachers to use in their planning and preparation. The outline and worksheet should prove beneficial to teachers in enhancing their use of various instructional practices, in identifying appropriate teaching behaviors and process decisions, and in documenting teaching techniques selected.

An Instructional Strategy Approach

Setting the Stage

This course has the potential to provide one of the most powerful instructional and learning environments in the public school system. Both the manufacturing and construction industries are experiencing rapid transition in their respective technologies both in terms of materials and processes. Consider if you would that eighty-five percent of the technology that will be in place by the year 2000 has not even been invented yet. If this idea is even half accurate, the implications are beyond comprehension. It is our students who will be responsible for many of these inventions, and we have a tremendous responsibility to help develop the personal skills that they will need to meet the challenges ahead.

The trend in education in the next few years seems to be headed in the direction of math, science, and technology. The math and science teachers have their tasks set and are meeting their own challenges. As Industrial Technology Education instructors, we have the responsibility and the resources to teach technology to as many students as we can muster. Through Industrial Technology Education we have the potential to bring the practical application of both math and science into meaningful experiences for high school students.

Instructional Strategy

As the preliminary material for this activity guide was prepared, several approaches were considered. The one primary concept that we felt should carry through much of the guide is that of *problem solving*. Problem solving brings the element of critical thinking into our instructional program and challenges students at all levels to develop skills which last a lifetime, no matter how rapidly technology changes. Problem solving through critical thinking may very well be the most important element that we can teach to our students in the next decade.

Another instructional strategy that will be important for Industrial Technology teachers to use in the coming years is *teamwork*. Teamwork is an important element in both the manufacturing and construction industries. Project teams, think tanks, and design groups represent what industry uses to solve problems in design, production, and management. While we have the responsibility to develop individual skills in our students, we also need to develop skills in the area of teamwork. One way to develop these skills is through *simulation* and *role playing* to mirror the design, production, and management functions of industry.

Teachers should also look at instruction methods which they are currently using in the classroom and continue to use them if they are effective in meeting the essential elements. One very important technique that Industrial Technology teachers have been using successfully is the *demonstration* method. Teacher demonstrations will continue to be a very important instructional strategy. The *lecture* is also a basic instructional strategy that will continue to be an important teaching tool.

Another important way in which Industrial Technology teachers can use the strengths of our program is to work with instructors from the math and science departments to generate team instructional activities. We have the potential to bridge the gap between these departments and our own practical approach to many of the same concepts. The potential for such joint ventures in learning is great and the timing is appropriate.

Strategies for Special Needs Students

Traditionally, Industrial Technology Education instructors have been receptive to including special needs students in their programs. Students with hearing, visual, and other physical handicaps; those with learning and behavioral disorders; the gifted and talented; and those with slow and retarded learning disabilities have all benefited from the attention given them by interested Industrial Technology Education instructors.

Now that we are entering a new era in which our instructional base is becoming more theoretical and more technological, the special needs students must not be left behind. Our transition into the new curriculum areas is happening at a time when mainstreaming of special needs students is on the increase. As you prepare lessons for the Production Systems course, remember that your program continues to provide individual learning activities that—

1. use concrete learning versus abstract learning;
2. provide visual instruction;
3. continue to provide much-needed hands-on experiences; and
4. provide time for individual instruction.

Take advantage of the resources available on your local campus, as well as those within the school district or community. One of the most effective resources available to teachers is the use of peer tutoring in the classroom. Also, seek the help of resource teachers to help plan or modify existing learning activities. Contact community agencies to find adult aides who might be available to help students on a one-to-one basis.

In using this laboratory activity guide for instructional planning, consider each activity as a beginning point from which to expand. All of the activities can be modified to meet the needs of most special needs students. Consider the following list of modifications as you look for various activities to use with students.

1. Use both visual and verbal instruction.
2. Make use of modeling or simulation.
3. Include thorough demonstration processes.
4. Provide immediate feedback and positive reinforcement.
5. Organize instruction to guarantee success for special needs students.
6. Use sequential steps in processes that are not overly complex, and provide for repetition as needed.
7. Use real-life examples in instruction to help reinforce the importance of the learning activities.

Instructional Planning Outline

Domain I. Instructional Strategies

Criterion 1. Provides opportunities for students to participate actively and successfully

Indicator:
- a. appropriately varies activities
- b. interacts with students in group formats as appropriate
- c. solicits student participation
- d. extends students' responses/contributions
- e. provides ample time for students to respond to teacher questions/solicitations and to consider content as it is presented
- f. implements instruction at appropriate level of difficulty

Criterion 2. Evaluates and provides feedback on student progress during instruction

Indicator:
- a. communicates learning expectations
- b. monitors students' performances as they engage in learning activities
- c. solicits responses or demonstrations from specific students for assessment purposes
- d. reinforces correct responses
- e. provides corrective feedback, or none needed
- f. reteaches, or none needed

Domain II. Classroom Management and Organization

Criterion 3. Organizes materials and students

Indicator:
- a. secures student attention, or students are attending
- b. uses administrative procedures and routines which facilitate instruction
- c. gives clear administrative directions for classroom procedures or routines, or none needed
- d. maintains seating arrangements/grouping appropriate for the activity and the environment
- e. has materials, aids, and facilities ready for use

Criterion 4. Maximizes amount of time available for instruction

Indicator:
- a. begins promptly/avoids wasting time at the end of the instructional period
- b. implements appropriate sequence of activities
- c. maintains appropriate pace
- d. maintains focus
- e. keeps students engaged

Criterion 5. Manages student behavior

Indicator:
- a. specifies expectations for class behavior, or none needed
- b. uses techniques to prevent off-task behavior, or none needed
- c. uses techniques to redirect off-task behavior, or none needed
- d. uses techniques to stop inappropriate behavior, or none needed
- e. uses techniques to stop disruptive behavior, or none needed
- f. applies rules consistently and fairly
- g. reinforces appropriate behavior when appropriate

Domain III. Presentation of Subject Matter

Criterion 6. Teaches for cognitive, affective, and/or psychomotor learning and transfer

Indicator:
- a. begins instruction/activity with an appropriate introduction
- b. presents information in an appropriate sequence
- c. relates lesson content to prior or future learning
- d. provides for definition of concepts and description of skills and/or attitudes and interests
- e. provides for elaboration of critical attributes of concepts, psychomotor skills, and/or attitudes and interests
- f. stresses generalization, principle, or rule as a relationship between or among concepts, skills, and/or attitudes/interests
- g. provides opportunities for transfer
- h. closes instruction appropriately

Criterion 7. Presents information accurately and clearly

Indicator:
- a. makes no significant errors
- b. uses vocabulary appropriate to students
- c. explains content and/or learning tasks clearly
- d. stresses important points and dimensions of content
- e. clarifies student misunderstanding, or none needed

Criterion 8. Uses acceptable communication skills

Indicator:
- a. uses correct grammar
- b. pronounces words correctly and clearly
- c. uses accurate language
- d. demonstrates skill in written communication

Domain IV. Learning Environment

Criterion 9. Uses strategies to motivate students for learning

Indicator:
- a. relates content to student interests/experiences
- b. emphasizes the value/importance of the activity or content
- c. reinforces learning efforts of students
- d. challenges students

Criterion 10. Maintains supportive environment

Indicator:
- a. avoids sarcasm and negative criticism
- b. establishes climate of courtesy and respect
- c. encourages slow and reluctant students
- d. provides praise for specific performance
- e. establishes and maintains positive rapport with students

Domain V. Growth and Responsibilities

Criterion 11. Plans for and engages in professional development

Indicator:
- a. shows progress in completing professional growth requirements as agreed upon with appraiser(s), or none needed
- b. stays current in content taught
- c. stays current in instructional methodology

Criterion 12. Interacts and communicates effectively with parents

Indicator: a. initiates communications with parents about student performance and/or behavior when appropriate
b. conducts parent-teacher conferences in accordance with local district policy
c. reports student progress to parents in accordance with local district policy
d. maintains confidentiality unless disclosure is required by law

Criterion 13. Complies with policies, operating procedures, and requirements

Indicator: a. follows statutory and Texas Education Agency regulations
b. follows district and campus policies and procedures
c. performs assigned professional duties
d. follows district promotion/retention policy and procedures

Criterion 14. Promotes and evaluates student growth

Indicator: a. participates in campus goal-setting for student progress
b. plans instruction in accordance with district requirements
c. documents students' progress
d. maintains accurate records
e. reports student progress at appropriate intervals

Instructional Planning Worksheet

Essential Element(s): ____________
TAAS Objective(s): ____________
Curriculum Guide Page: ____________

Objective: At the conclusion of the lesson the learner will be able to:

Focus Activity: ____________

a. Task for lesson ____________

b. Value of lesson to learner is ____________

Explanation / Check Understanding:

a. ☐ Lecture ☐ Overhead ☐ Demonstration ☐ ____________
b. ☐ Curriculum Guide page ____ ☐ Text page ____ ☐ ____________
c. Modeling (teaching will) ____________
d. Key questions to check understanding:
  1. ____________
  2. ____________
  3. ____________
  4. ____________
  5. ____________
  6. ____________

Guided Practice Exercise:

☐ Exercise copied from overhead ☐ Hand out Worksheet No.____________

☐ Copy from board ☐ Read sample problems ☐ ____________

____

____

Checking Mastery (Learning Progress):

☐ View each student's work ☐ Students check and signal correct

☐ ____________________________

____

Independent Practice (Reteach those needing help while others work):

☐ Worksheet No.________ ☐ Copy from overhead ☐ Copy from board

☐ Copy as dictated ☐ Reteach worksheet/outline number ____________

☐ ____________________________

☐ ____________________________

Extension (Enrichment/Application):

☐ Worksheet No.________ ☐ ____________________

Describe how this activity makes relevant application of the lesson: ____________

____

____

____

Closure (Restate the learning): ____________________

____

Method to involve the learner in the summary: ____________________

____

Sponge Activities: Sponge Focus Activity No. ____________________

Other Sponge Activity No. ____________________

Essential Elements Common to All Industrial Technology Education Programs

75.85 The elements in this subsection are common to all Industrial Technology Education courses unless otherwise indicated and shall be included in each course at the appropriate level. They are described here to preclude repetition in each course. Every school offering industrial technology education shall provide courses which include the following essential elements.

1. Leadership concepts and skills. The student shall be provided opportunities to:
   - A. demonstrate skills, characteristics, and responsibilities of leaders and effective group members;
   - B. demonstrate a knowledge of parliamentary procedure principles;
   - C. plan and conduct leadership activities; and
   - D. prepare for effective citizenship and for participation in our democratic society.

2. Concepts and skills related to successful employment and/or postsecondary training. The student shall be provided opportunities to:
   - A. identify employment opportunities and preparation requirements in chosen fields;
   - B. identify effective methods to secure and terminate employment;
   - C. demonstrate effective communication skills, both oral and written, and follow through on assigned tasks;
   - D. demonstrate dependability and punctuality;
   - E. demonstrate productive work habits and attitudes;
   - F. understand the importance of taking pride in the quality of work performed;
   - G. recognize the dignity in work;
   - H. develop skills in planning and organizing work;
   - I. apply required methods and sequences when performing tasks;
   - J. apply principles of time management and work simplification when performing assigned tasks;
   - K. identify ethical practices and responsibilities; and
   - L. understand the importance of the application of organizational policies and procedures.

3. Concepts and skills associated with entrepreneurship. The student shall be provided opportunities to:
   - A. identify opportunities for business ownership;
   - B. understand the risk and profit motive factor;
   - C. understand the elements and advantages of the free enterprise system; and
   - D. explain the role of small business in the free enterprise system.

4. Concepts and skills associated with human relations and personality development. The student shall be provided opportunities to:
   - A. understand the importance of maintaining good health and proper appearance for effective job performance;
   - B. understand oneself and others;
   - C. exercise self-control;
   - D. accept and use criticism;
   - E. recognize basic human relationships as they relate to business success; and

F. demonstrate characteristics for successful working relationships.

5. Concepts and skills related to personal and business management. The student shall be provided opportunities to:
    A. explain how management assists in reaching personal and family goals;
    B. explain the management process;
    C. describe the role of management in controlling stress;
    D. identify and understand personal checking accounts;
    E. identify and understand personal loan application processes;
    F. identify and understand different financial institutions;
    G. identify the role and functions of business management;
    H. understand the lines of authority; and
    I. identify effective supervisory techniques.

6. Concepts and skills related to the application of safety practices. The student shall be provided opportunities to:
    A. demonstrate safe operation of appropriate tools, machines, and equipment;
    B. maintain a safe and clean laboratory environment; and
    C. investigate appropriate state and federal safety laws.

7. Concepts and skills related to social/cultural impacts of technology. The student shall be provided opportunities to:
    A. investigate ideas and technological developments of the past and present;
    B. assess the characteristics of technological change on society and culture;
    C. predict how selected technological developments will impact future cultures and societies; and
    D. explore the impact technology has on the environment.

8. Concepts and skills related to the application of technology to daily life. The student shall be provided opportunities to:
    A. evaluate selected products based on given standards or applications;
    B. develop criteria for selecting, purchasing, and contracting services;
    C. practice the servicing of selected products and equipment of technology;
    D. investigate the interrelationship of all technology areas;
    E. use computer-controlled systems and/or devices related to each course; and
    F. apply the design process to product development.

9. Concepts and skills related to the tools, materials, and processes of technology. The student shall be provided opportunities to:
    A. become proficient in the use of appropriate tools, machines, and equipment;
    B. analyze the properties of a wide range of materials of technology through testing;
    C. explore the processes of various technologies; and
    D. investigate and practice conservation and recycling of products and materials of technology.

10. Concepts and skills related to the application of problem-solving techniques. The student shall be provided opportunities to:
    A. identify and creatively solve technological problems using the scientific method;

B. explore standards of measurement used in technology and apply measurement in the solution of problems; and
C. communicate oral, written, and computational technical information.

Production Systems Essential Elements

Production systems, 11601400. PS (1/2-1 unit). Production systems is a laboratory-oriented course that includes the common essential elements for industrial technology education, plus concepts and skills related to production systems. The student shall be provided opportunities to:

1. describe the types of metallic, polymer, ceramic, organic, and composite materials used in production;
2. identify types and grades of materials;
3. trace the transformation of raw materials into finished products;
4. organize an enterprise to construct a structure or to produce a product;
5. conduct tests to evaluate the strengths of materials;
6. illustrate the different classifications of structures;
7. compare the management components of the construction and manufacturing industry;
8. illustrate the manufacturing process from the idea of a product to the marketing of the product;
9. simulate automation systems used in the production of structures and products;
10. use the manufacturing components of planning, organizing, directing, and controlling personnel to design, engineer, produce, and market a product;
11. compare the relationships of the three construction subsystems: design, management, and building;
12. use the processes of forming, separating, combining, and conditioning;
13. calculate quantities and costs of appropriate production materials; and
14. explore space-based production systems.

Texas Assessment of Academic Skills (TAAS): Domains and Objectives

MATHEMATICS
GRADES 3, 5, 7, 9, AND EXIT LEVEL

DOMAIN: *CONCEPTS*

OBJECTIVES:

The student will:

1. demonstrate an understanding of the concepts of numbers
2. demonstrate an understanding of mathematical relations, functions, and other algebraic concepts
3. demonstrate an understanding of geometric properties and relationships
4. demonstrate an understanding of measurement concepts using metric and customary units
5. demonstrate concepts related to an understanding of probability and statistics

DOMAIN: *OPERATIONS*

OBJECTIVES:

The student will:

1. demonstrate skills, concepts, and applications related to addition
2. demonstrate skills, concepts, and applications related to subtraction
3. demonstrate skills, concepts, and applications related to multiplication
4. demonstrate skills, concepts, and applications related to division

DOMAIN: *PROBLEM SOLVING*

OBJECTIVES:

The student will:

1. estimate solutions
2. analyze problems and identify solution strategies
3. express problems using mathematical representations
4. evaluate the reasonableness of problem solutions

ENGLISH LANGUAGE ARTS
GRADES 3, 5, 7, 9 AND EXIT LEVEL

DOMAIN: *READING COMPREHENSION*

OBJECTIVES:

The student will:

1. determine the meaning of words
2. identify supporting ideas
3. summarize written texts
4. perceive relationships and recognize outcomes
5. analyze information to make inferences/generalizations
6. recognize points of view, propaganda, and/or fact and nonfact

DOMAIN: *WRITTEN COMMUNICATION*

OBJECTIVES:

The student will:

1. respond appropriately to the purpose/audience in a written composition
2. organize ideas in a written composition
3. demonstrate control of the English language in a written composition
4. generate a written composition which develops and supports a central idea
5. recognize appropriate sentence construction
6. recognize appropriate word usage
7. recognize within the context of a written passage:
    - (a) the correct spelling of words
    - (b) correct capitalization
    - (c) appropriate punctuation

Production Systems
Course Description and Content Outline

9-12 Grades, 1/2-1

Production Systems is an activity-based course introducing students to the concepts of manufacturing and construction technology. In the manufacturing component, students focus on the material processing and management practices used in our free enterprise economic system. In the construction component, students focus on the preconstruction, construction, and postconstruction practices and management techniques used in the industry. Examples of student learning activities are: organize an enterprise, design and produce products, make jigs and fixtures, plan residential developments, conduct material testing, estimate the cost of a product, conduct product research, build a model space factory, and build a structure. Examples of equipment used are: computer-aided-drafting (CAD) equipment, computer hardware/software, test equipment, robots, transits, computer-aided drafting/computer aided-manufacturing (CAD/CAM) equipment, and general production equipment.

Essential Elements	Suggested Content Outline	Suggested Learning Activities
	I. Introduction	
	A. Overview	
	1. Define production	
	2. Production in a changing society	
75.85.5B, 75.85.5H	a. Organization of production systems	Collect illustrations of types of production systems.
75.85.5B, 75.85.5G, 75.85.5H	b. Management systems	
75.85.5H	c. Researching, producing, and marketing a product	Develop a flowchart illustrating the development of a product.
75.85.5E, 75.85.5F	d. Production facilities	
75.85.5E, 75.85.5F	e. Financing production systems	Compare various lending institutions.
	3. Careers	
75.85.2A	a. Instruction training systems	List qualifications for employment.
75.85.2A	b. Career information sources	Career guidance inventory, DOT information, computer career search. Counselor presentation.
75.85.2A	c. Preparing for productive employment	
75.85.2C	(1) Job application	Write letter of application, fill out job application.
75.85.2C	(2) Job interview	Video role playing of job interview.
75.85.2C	(3) Employment searches	Newspaper ads, guest speaker from TEC
75.85.5A, 75.85.5D	d. Personnel development	
75.85.5C, 75.85.6C	(1) Safety	Identify general safety procedure use at home.
75.85.2C, 75.85.2L	(2) Hiring	Guest speaker, newspaper ads
75.85.2A	(3) Training	List educational requirements.
75.85.2E	(4) Working	Check list of working conditions, salary.
75.85.2C,		

75.85.2L	(5) Advancing	Ability, education, commitment, experience, guest speaker
75.85.2A	(6) Retraining	Role play—changing skills
75.85.2B	(7) Resigning	Write letter of resignation; include reason for leaving. Talk about psychological impact.
75.85.2C	(8) Retiring	Planning, retired person as speaker, Social Security
75.85.2A	(9) Industrial organizations	Guest speak from labor union
	B. Impacts of production systems	
75.85.7A	1. Past	
75.85.7B	a. History of production	Develop a history date line.
75.85.7B	b. Social/cultural	Research Industrial Revolution; illustrative wall chart.
	2. Present	
75.85.7A	a. Importance of production systems	Brainstorm reasons for importance.
75.85.7B	b. Economic value	Research prices/salaries of 1900 and 1988.
75.85.7D	c. Environmental impacts	Class analyze the effects of the steel, oil, and auto industries on the economy and the environment.
75.85.7C	3. Future	
75.85.7C	a. Resources	Investigate current breakthroughs and the effect of the changes on our way of life in terms of economics, processes, resources, technology applications, and social impacts.
75.85.7C	b. Processes	
75.85.7C	c. Tools	
75.85.7C	d. Applications	
75.85.7C	e. Social/cultural impacts	
75.85.8D	C. Interrelationship of technologies	
75.85.9C	1. Common industrial technologies	Compare communication, energy/power, transportation, and production technologies in terms of common tools, processes, materials. Identify the dependencies of each technology on the others.
75.85.8D	2. Communication technology	
75.85.8D	3. Energy/power technology	
75.85.8D	4. Transportation technology	
75.85.8D	5. Changing technology	Give examples of how changes in one technology affect other technologies.
75.85.9C	D. Interrelationship of technology to other disciplines	
75.85.9C	1. Mathematics	Have the class brainstorm the use of each discipline as it applies to a product.
75.85.9C	2. Science	
75.85.9C	3. Social Studies	
75.85.9C	4. Language Arts	
	II. Elements of Production Technology	
75.85.9A	A. Tools	
75.85.9A	1. Hand	Demonstrate the use of basic hand tools and portable power tools.
75.85.9A	2. Power	
75.85.107	a. Electrical	Films, demonstrations, hands-on activities to show uses of electrical tools, hydraulic tools, pneumatic tools, computers, and computer-aided systems
75.85.107	b. Hydraulic	
75.85.107	c. Pneumatic	
75.85.107	d. Computer	

75.85.107	e. Computer systems	
	(1) CNC	Program CNC for simulation on actual project.
	(2) CAD/CAM	Prepare a model of a CAD/CAM system.
	(3) CIM	Draw a diagram to illustrate CIM.
	(4) Computer-controlled systems	Collect pictures to illustrate various computer-controlled systems.
75.85.10B	3. Measuring	
75.85.10B	a. English	Use appropriate measuring system as it applies to the construction of a product.
75.85.10B	b. Metric	
75.85.101, 75.85.99, 75.85.100	B. Materials	
	1. Types	Collect samples of various materials and classify them as natural or synthetic.
	a. Natural	
	b. Synthetic	Identify synthetic materials used in manufacturing a car or building a bridge.
75.85.9B	2. Properties	Filmstrips, videos
75.85.9B, 75.85.103	3. Testing	Use lab-made testing equipment to demonstrate industrial testing procedures.
75.85.26B, 75.85.100	4. Standard stock	Chart showing physical characteristics of various materials
75.85.10C, 75.85.111	5. Quantity/Cost	Prepare a bill of materials.
75.85.110	6. Finishing	Use proper finishing techniques for various kinds of materials. Conduct experiments to determine best finish for a material under varying conditions.
75.85.101	7. Storage	Collect photographs showing storage facilities for selected materials.
75.85.26E, 75.85.103	8. Use	Conduct an experiment to decide the best material to use.
75.85.100	9. Selection	Select a product and discuss advantages and disadvantages of materials as they relate to the product.
75.85.7D	10. Environmental impact	Write a report.
	C. Processes	
75.85.9C, 75.85.10A	1. Design and problem solving	Practice the design process by solving one or more of the following tasks: Mousetrap car CO_2 car Candle carrier Robot arm CAD/CAM workstation
75.85.106	a. Identify task	
75.85.106	b. Preliminary ideas	
75.85.106	c. Refinement	
75.85.106	d. Analysis of solutions	
75.85.106	e. Determine best solution	
75.85.106, 75.85.108	f. Implement solution	
75.85.9C	2. System model	

75.85.9C	a. Input	Select a commercially made product. Then identify how each part of the system model applies to it.
	(1) People	
	(2) Materials	
	(3) Information	
	(4) Capital	
	(5) Energy	
75.85.108, 75.85.9C	b. Processing	
75.85.108	(1) Material handling	
75.85.108	(2) Material processing	
75.85.108	(3) Assembly methods	
75.85.108	(4) Distribution	
75.85.9C	c. Output	
	(1) Construction	
	(a) Mass	
	(b) Bearing	
	(c) Frame	
	(2) Manufacturing	
	(a) Parts	
	(b) Components	
	(c) Products	
75.85.9C	d. Feedback	
	(1) Positive	
	(2) Neutral	
	(3) Negative	
75.85.9C, 75.85.10A	3. Research and development	
75.85.8F	a. Research principles	Research a product to produce and market.
75.85.8F, 75.85.10A	b. Problem-solving principles	
75.85.108	4. Quality assurance	
75.85.108	a. Sampling technique	Make a list of characteristics to check to assure a quality product.
75.85.108	b. Classification of defects	Make a list of quality control procedures.
75.85.108	c. Acceptance or rejection	
75.85.108	5. Space	
75.85.112, 75.85.100, 75.85.101	a. Materials	Film from NASA showing tools and materials that are used in space
75.85.112, 75.85.9A	b. Tools	
75.85.112, 75.85.104	c. Construction	Simulate construction and manufacturing in space. Build a model athletic complex for use in space.
75.85.112, 75.85.104, 75.85.108	d. Manufacturing	Design and build a model space vehicle.
75.85.9C, 75.85.112	e. Processes	
	D. People	
75.85.5A, 75.85.5D, 75.85.5E, 75.85.5F	1. Personal/family management	Prepare a family budget.

75.85.1A, 75.85.1D	2. Leadership	Student management system, student organization, or club
75.85.5B, 75.85.5G, 75.85.5H, 75.85.105	3. Management	Form a classroom management system.
75.85.3A, 75.85.3D	4. Entrepreneurship	Use a guest speaker to share information on entrepreneurship.
75.85.4A, 75.85.4F	5. Human relations and personality	Students will develop skills in this area as class progresses.
75.85.10C	E. Information	
75.85.10C	1. Sending and receiving	Use a computer to develop a letter to ask for information.
75.85.10C	2. Categorizing	Use a computer data base to categorize magazine articles.
75.85.10C	3. Handling	
	F. Safety	
75.85.6A, 75.85.6B	1. Maintenance of equipment	Select a commercially made product and prepare a maintenance procedure for it.
75.85.8C	2. Repair of equipment	Repair broken or worn equipment as needed.
75.85.8B	3. Contracting services	Compare the services, prices, equipment of a cordless drill.
	III. Applications of Production Systems	
	A. Processes	
75.85.9C	1. Common	
75.85.101	a. Casting	Design and build a mold for plaster (or metal) casting.
75.85.101	b. Forming	Demonstrate methods of forming, separating, assembling, conditioning, and finishing different materials. Make a chart showing how each process is used for different materials.
75.85.101	c. Separating	
75.85.101	d. Assembling	
75.85.101	e. Conditioning	
75.85.101	f. Finishing	
75.85.102	2. Preconstruction	
75.85.108, 75.85.109	a. Determine needs	Organize the class into a construction company. Using the construction process, construct a model of one of the following: Road Airport terminal Shopping center Underwater tunnel Dam Home Refinery Space facility
75.85.108, 75.85.109	b. Site selection	
75.85.8F, 75.85.109	c. Design criteria	

75.85.108, 75.85.109	d. Planning	
75.85.111, 75.85.109	e. Cost estimates	
75.85.108, 75.85.109	f. Scheduling	
75.85.109	g. Contracting	
	3. Construction	
75.85.104, 75.85.109, 75.85.108	a. Types of construction	
	(1) Light	Make a poster to illustrate the types of construction.
	(2) Heavy	
	(3) Industrial	
	(4) Civil	
75.85.5E	b. Capital	
	(1) Site	Guest speaker: contractor, savings and loan officer
	(2) Funding	
	c. Quality control	
75.85.109	4. Postconstruction	
75.85.109	a. Finishing/Landscape	Guest speaker: nursery owner
75.85.8B, 75.85.8C	b. Servicing/Maintenance	
75.85.109	c. Altering	
75.85.109	5. Premanufacturing	
75.85.10A, 75.85.102	a. Research	Organize the class into a manufacturing company. Using the manufacturing process, build one of the following: Salt and pepper shakers Machine part Toy car Gumball machine Nutcracker Tic-tac-toe game
75.85.8F	b. Design/Development	
75.85.8F	c. Mock-ups	
	6. Manufacturing	
75.85.108	a. Types of processes	
	(1) Custom	Prepare a chart to illustrate each type of manufacturing process.
	(2) Intermittent	
	(3) Mass	
	(4) CAD/CAM	
	(5) FMS	
	(6) JIT	
75.85.108	b. Planning	
75.85.108	c. Organization	
75.85.108	d. Controlling production	
75.85.108	e. Quality control	Build a light-sensitive device to illustrate quality control of a painted object.
	7. Postmanufacturing	
75.85.108	a. Packaging	Design a container for a fast-food place.
75.85.108	b. Storage	
75.85.108	c. Shipping	Design a shipping container for some fragile product.

75.85.108	d. Marketing	
75.85.10C, 75.85.111	e. Cost/profit accounting	
75.85.8C	f. Servicing/maintenance	Explore product servicing for a mass-produced product.
	IV. Impacts of Production Systems	
	A. Consumer	
75.85.8A, 75.85.8B	1. Products	Write an environmental impact statement for the construction/manufacturing products that are developed.
75.85.8A, 75.85.8C	2. Services	
75.85.7D	B. Environment	
75.85.7C	C. Social/Cultural	
75.85.7B	D. Economic	Identify the economic value of the construction or manufacturing products that are developed.
75.85.9D	E. Conservation	
75.85.9D	1. Economic	
75.85.9D	2. Environmental	Identify environmental problems within your lab, city, and state.
75.85.7D, 75.85.6C	a. Pollution	
75.85.9D	b. Preservation	
75.85.9D	c. Alternatives	
75.85.9D	3. Recycling	Select an item your class can recycle.
75.85.102	V. Production Systems Enterprise	
75.85.10A	A. Research and Development	
75.85.6C	B. Construction and Manufacturing	
75.85.3A, 75.85.3D	C. Entrepreneurship	
75.85.1A, 75.85.1D, 75.85.5B, 75.85.105, 75.85.109	D. Management	Simulate a construction or manufacturing firm.
75.85.10C, 75.85.108	E. Marketing	
75.85.8F, 7.585.108	F. Advertising	
75.85.2A, 75.85.2L	G. Personnel	
75.85.5F, 75.85.10C	H. Financial	
75.85.8B	I. Servicing	
75.85.5C	J. Maintenance	
75.85.8C	K. Supplies	
75.85.8C	L. Equipment	

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 1
(1 WEEK)

PRODUCTION MATERIALS

Essential Elements: Common: 1A, D; 2C-F, H, I; 3B; 4C; 5B; 6A-C; 7A-D; 8D-F; 9A-D; 10A, C
Specific: 3
TAAS Objectives: Math: C 3; O 1, 2; PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

This unit will introduce the students to different materials used in the production processes. Students will learn about the basic processes that these materials go through to become products.

Teaching Tips

1. Invite a speaker on recycling to talk to the class about the importance of recycling. Set up a recycling program at your school, i.e., for soda cans, paper, etc.
2. Identify suppliers that might have scrap materials, such as composites, which you might not have as one of the normally used materials in your production classes.
3. This will serve as a good introductory unit to familiarize students with the materials and processes used in the production of products.

Instructional Strategy

- This unit is mostly for exploration. The students should be able to work in the lab with as many materials as possible. They should be able to practice all of the manufacturing processes and also use the four forces on the materials.
- Have students work in groups of 3 to 5 to test materials and processes.

Equipment/Supplies

1. Samples of different materials
2. Tools to manipulate materials

Evaluation Key

1. List three basic production materials.
   A. Metal
   B. Wood
   C. Composites
   Plastic
   Ceramic

2. List four of the six major processes used to manipulate materials.
   A. Casting and molding
   B. Forming
   C. Separating
   D. Conditioning
   Assembly
   Finishing

3. Identify two social issues related to recovering materials.
   A. Landfills and garbage dumps are full
   B. Need to protect our natural resources

4. Explain the importance of recycling materials.

Recycling materials helps the environment by protecting natural resources and finding new alternatives to using garbage dumps and landfills for our trash.

Production Processes and Materials

	Metal	Sheet	Rod	Cold rolled	Hot rolled	Aluminum	Brass	Copper	Polymer	Lumber	Plywood	Paper	Cardboard	Plastic	Ceramic	Slip	Clay	
Casting																		
Molding																		
Forming																		
Separating																		
Cutting																		
Sawing																		
Torch																		
Conditioning																		
Assembly																		
Nuts & Bolts																		
Screws																		
Nails																		
Glue																		
Rivet																		
Weld																		
Finishing																		
Spray																		
Paint																		
Tung Oil																		

PRODUCTION MATERIALS

Learn about the basic processes that different materials used in production processes go through to become products.

Objectives

- To list the basic production materials
- To list the major processes used to manipulate materials
- To identify social issues related to recovering materials
- To explain the importance of recycling materials

Vocabulary/Concepts Reinforced

- Recycling
- Materials
- Processes
- Composites

Equipment/Supplies

- Samples of different materials
- Tools to manipulate materials

Introduction

Look at the classroom around you. How many different types of materials can be found? Create a list on the chalkboard. Technological advances have created new types of materials, such as composites, that can be added to the list of materials from which products can be made that already included metal, wood, plastic, and ceramic.

New metal and plastic composites can provide more strength than in previous materials and have other benefits. Composites are made up of several distinct components or parts. Metal and plastic composites have new additives that previous materials did not have. Ceramics (not the types used in art class to make dishes or vases) have good temperature withstanding properties and are used in the automotive, aircraft, and electronic industries. In this unit, we will look closer at some materials and the processes used to alter the materials to produce a final product.

Metals. Metals are mineral substances whose atomic structures are crystalline in nature and can conduct electricity. Different combinations of minerals produce different metals. Coins are a good example of different combinations of metals to produce different weights and colors that are strong enough to withstand constant handling. Aluminum foil, on the other hand, is not designed to withstand constant handling or hold a shape the way coins do. Different types of metals used in alloys might include tin, zinc, magnesium, aluminum, copper, nickel, cobalt, and titanium. Different combinations of these metals have different properties, such as corrosion resistance, elevated temperature strength, electrical conductivity, shear strength, weight-bearing capabilities, or melting point considerations. Metals are melted and formed into ingots for further processing.

Composites. Probably the earliest composite was bricks made from clay with straw added. Currently used composites are different not only because of the materials used, but also because of the ways those materials are combined. Fibers or particles are used to reinforce the base material, which is usually metal or plastic.

Plastics. Plastics were developed when there was a shortage of metal. A synthetic material, plastics are developed from petroleum products. They can be divided into two categories: thermosets and thermoplastics. Thermoset plastics harden as a result of a chemical reaction and cannot be softened upon reheating. Thermoplastics do not undergo a chemical change and can be reheated and reshaped. The following advantages and disadvantages apply to plastics in general:

Advantages:

1. Light weight
2. Chemical resistance
3. Thermal and electrical insulation properties
4. Long life

Disadvantages:

1. Poor resistance when heat is applied
2. Low strength

Wood. Wood is an organic material that is used mostly for furniture, paper products, and sports equipment. Because newer materials have been developed, fewer products are being manufactured from wood.

Manufacturing processes. The major processes used in manufacturing include casting and molding, forming, separating, conditioning, assembly, and finishing. Nontraditional processes include abrasive jet machining, water jet machining, abrasive water jet machining, abrasive flow machining, ultrasonic machining, ultrasonic welding, high-energy-rate forming, electromechanical machining, electromechanical grinding, electromechanical discharge grinding, electrostream drilling, shaped tube electrolytic machining, chemical machining, electrical discharge machining, electrical discharge wire cutting, electrical discharge grinding, electron beam welding, electron beam machining, laser processing, plasma arc cutting, and thermal energy deburring.

In this unit we will focus on the traditional processes of manufacturing. Primary manufacturing processing takes raw materials and changes them into industrial stock: trees are debarked and cut into planks for lumber, petroleum goes through the cracking process and is changed into over twenty different by-products which are then used to make synthetic fibers and fuels. Secondary processing uses the industrial stock to make consumer products. Lumber is made into furniture, cold rolled steel into auto parts, etc.

The casting and molding process uses a shaped cavity as a form into which a liquid is forced. Once the liquid solidifies, it is removed from the mold and the rough edges are cleaned up. A simple example of the casting and molding technique is the way Jell-O is poured into a mold and sets into that shape. Forming processes cause the material to take on a new shape through applied pressure and shaping devices. Temperature can also play a part in this process. Toothpaste being squeezed out of the tube is an example of the forming process.

The separating process removes extra material with the use of a tool. An example would be cutting out a shape on the band saw. The conditioning process alters the chemical makeup of the material and will change the hardness or ductility of the material. Conditioning takes place usually after heat has been applied, although there are also mechanical and chemical processes as well.

The assembly process is putting more than two pieces together to create a product. Some type of fastener, such as screws, nails, welds, etc., is used to hold parts together. The finishing process involves coating the product or parts of it to protect it and enhance the way it looks.

All materials used in manufacturing have chemical and mechanical properties. The chemical properties are a result of the molecular structure of the material. Different molecular structures produce different materials. The mechanical properties reflect the ability of the material to resist the application of a force or load. In *Processes of Manufacturing,* Thomas Wright identifies four types of force: compression, tension, shear, and torsion. Compression is trying to force the material into a smaller space than it currently occupies. Tension is created by stretching the material beyond its original intended shape and size. Shear is caused by exerting two opposing forces against a material. Torsion is caused by a twisting motion and is similar to shear except that the material is usually round.

Social issues related to materials revolve around excess materials and removing them from the work site or home. Many excess materials can be recycled. Recycling is the process of separating excess materials into piles of like materials and processing those materials such that they can be used again. Many towns and communities have started recycling programs for homes because garbage dumps and landfills are becoming crowded and full. All of the extra garbage needs to go somewhere. Home recycling programs usually include glass, plastic, paper products, and metal.

Another issue related to the recovery of materials to be processed again is that of harvesting more trees, mining more metals, and pumping more petroleum from the ground. These processes remove natural resources from the earth. There is only so much petroleum and metal that can be removed from the ground. When it's gone, it's gone. Trees can be planted to replace those that were harvested, but it takes 30 to 50 years for most trees to mature to a point where they can be used. So, to protect our natural resources, recycling is an important social initiative.

Your teacher should have some materials ready for you to demonstrate the different processes and forces that can affect materials. You should conduct as many tests as possible on the materials provided.

Procedure

1. Study production materials.
2. Study production processes.
3. Use samples to demonstrate effect of production processes on materials.

Evaluation

1. List three basic production materials.
    A.
    B.
    C.

2. List four of the six major processes used to manipulate materials.
   A.
   B.
   C.
   D.

3. Identify two social issues related to recovering materials.
   A.
   B.

4. Explain the importance of recycling materials.

Support Materials

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- Benedict, Gary F. *Nontraditional Manufacturing Processes.* New York: Marcel Dekker, Inc., 1987.
- Gackenbach, R.E. *Materials Selection for Process Plant.* Reinhold Publishing Corp., 1960.
- Wright, Tom. *Processes of Manufacturing.* South Holland, Ill.: Goodheart-Willcox Co., Inc., 1987.

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 2
(1 WEEK)

PRODUCTION PROCESSES

Essential Elements: Common: 2A, C, H, I; 4F; 7B; 8A; 10C
Specific: 3, 12
TAAS Objectives: Math: PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

Students will analyze food products for their contents. They will determine all of the major steps required to get the product from the raw materials onto the store shelf. They will also conduct research on some of the chemicals found in foods, including writing to companies to find out more about the chemicals and their purposes. Students will identify careers related to food production and possibly invite a guest speaker to come talk to the class about careers in the field.

Teaching Tips

1. Select products that have several food sources as well as several chemicals. Ketchup, sauces, and relishes are a good start.
2. Cover the major steps in the production process: primary processes which turn raw materials into industrial stock, and secondary processes which combine parts or subassemblies into usable products. Six processes identified by Wright and Jensen are: casting and molding, separating, forming, conditioning, combining, and molding. Food production requires three of these—separating, conditioning, and combining. Usable portions of the food stock must be separated from the unusable (separating); foods must be cooked or blanched, freeze-dried or dehydrated (conditioning); and foods must be combined together to create products (combining). In addition, the packaging of foods is similar to the packaging of other products. The major concern in food processing is keeping the foods and containers sterile to prevent spoiling.
3. Have students work through the steps required to produce food products (use brainstorming as a way to get the steps listed):
   A. Farmers raise the crops and harvest the produce.
   B. Wholesalers buy up large quantities of produce and sell to manufacturers (except for organizations such as McDonald's, Del Monte, Hunt's, etc., which grow their own produce).
   C. Produce is transported to the food factories.
   D. Produce is made ready for production (i.e., cleaned, cut, chopped, etc.).
   E. Production of food products takes place through separating, conditioning, and combining.
   F. Sterile packaging of the food happens next.
   G. Labels are applied. Individual packages of food are boxed and prepared for distribution.
   H. Products are transported by truck or train or both to wholesale distribution points.
   I. Food is then shipped to individual stores for purchase by consumers.
4. Set up groups and assign (or allow students to select) products. Have students identify all of the steps necessary to get their product to the store. Have the students do research in the library on the different chemicals used in food products. They may also wish to write the food company for further information.
5. Have groups present their findings in a formal presentation.
6. Use a quiz to test the students' knowledge.

Instructional Strategy

- Team teach this unit with a science or home economics teacher. Other topics might include chemical analysis of food content in science lab, or nutritional information related to the amount of salt or sugar in processed foods.
- Set aside time at a date beyond the unit to incorporate responses from any food companies to whom the students may have written.
- Have the students work in small groups of 3 to 5. Group students according to ability so that all groups have a cross section of talent and ability.
- Have more than one guest speaker; have one guest stay for two classes, but no more than three, as it can be an imposition on her/his time.

Equipment/Supplies

1. Samples of processed foods: tomato ketchup, pickle relish, frozen dinner entrees, etc.
2. Poster board
3. Paper, markers, glue, paste, etc.
4. Research materials in school library

Evaluation Key

Group reports
Quiz answers

1. List the major steps in transforming raw food materials into finished products that might be found in a grocery store.
   A. planting, harvesting food
   B. transporting food to factory
   C. cleaning, sorting, separating
   D. cooking, combining, packaging
   E. transporting to store, stocking shelves

2. List two chemicals and the purpose of each.
   A. salt; preservative
   B. BHA; preservative

3. List two sources of information about chemicals that are found in processed foods.
   A. library
   B. food companies

PRODUCTION PROCESSES

Use sample products to trace the food production processes that transform materials from a raw state to a finished product. Explore careers in food production.

Objectives

- To read product labels
- To identify processed foods
- To list the necessary steps for processed food production
- To research food production processes
- To work safely in the lab
- To design a poster explaining food production

Vocabulary/Reinforced Concepts

- Processed foods
- Food production
- Raw materials
- Research
- Flowchart

Equipment/Supplies

- Samples of processed foods: tomato ketchup, pickle relish, frozen dinner entrees, etc.
- Poster board
- Paper, markers, glue, paste, etc.
- Research materials in school library

Introduction

It's dinner time. You're about to have a hamburger that was cooked on the grill. You pour on some ketchup and add some pickle relish. While eating your hamburger, you pick up the ketchup bottle and decide to read the label. It says, "Tomato paste made from red ripe tomatos, distilled vinegar, corn syrup, salt, onion powder, spice, natural flavoring." You are amazed at all of the ingredients. You start to think, "How does ketchup differ from spaghetti sauce?"

You head to the kitchen and find a jar of spaghetti sauce. Those ingredients are listed as, "Tomato paste, water, tomatos, corn syrup, corn or cottonseed oil, salt, concentrated lemon juice, dehydrated onions, dehydrated garlic, dehydrated parsley, spices (oregano, basil, and other spices), and natural flavoring." Some questions arise in your mind. "What do they mean by 'natural flavoring'? How can the addition of water, lemon juice, oil, and some dehydrated flakes make such a difference in two products?"

You decide to look at the pickle relish jar. It gets pretty scary when you read the entire list of ingredients: pickles, corn syrup, cauliflower, vinegar, salt, sugar, red peppers, spices, **xanthan gum**, **alum**, **turmeric**, natural flavors, **polysorbate 80**. What is xanthan gum? It doesn't sound like bubble gum to me!! What are these other *things* in my pickle relish: alum, turmeric, and polysorbate 80? They sound like the new car models for 1999!!

Some research is required here. How exactly do products get to the store shelf? What is required for raw materials (vegetables, spices, etc.) to become a product on the table? Do these processes differ greatly from those required to make a television or computer? What major chemicals are used in food production? What are the purposes of these chemicals?

Procedure

1. Select a product.
2. Analyze its contents.
3. Research chemicals. For more information use the library and write to companies that produce the food products.
4. Develop a report on chemicals; report to your class.
5. Create a list of processes that raw materials must go through to become products.
6. Design a flowchart to show a product's progress from field to factory to store.
7. Research careers in food production. Invite a speaker to come to class to talk about these careers.

Evaluation

1. Grade on group reports
    - A. Identify chemicals and their use in food production.
    - B. Develop a list of processes that raw materials must go through to become products.
    - C. Design a flowchart showing the steps from field to factory to store.
    - D. Identify three careers related to food production and provide a description of each.

2. Quiz
    1. List, in sequence, the major steps in transforming raw food materials into finished products that might be found in a grocery store.
        - A.
        - B.
        - C.
        - D.
        - E.

    2. List two chemicals and the purpose of each.
        - A.
        - B.

    3. List two sources of information about chemicals that are found in processed foods.
        - A.
        - B.

PRODUCTION ORGANIZATION

Essential Elements:	Common: 1A, D; 2C-F, H, I; 3B; 4C; 5B; 6A-C; 7A-D; 8D-F; 9A-D; 10A, C Specific: 3
TAAS Objectives:	Math: C 3, O 1, PS 3 Reading: 1-6 Writing: 6, 7

Activity Summary

Students will study the three types of production: mass, batch, and custom. They will produce the same product using two different methods and compare the differences.

Teaching Tips

1. Have books on reserve in the library or check them out for use in your classroom.
2. Have students create products, then conduct the batch and custom production runs for comparison.
3. Split the class into two groups and have one group run the batch production and the other the custom production. (This activity will also be covered in Activity 9, but with part of the production process automated.)

Instructional Strategy

- Module will require some research by the students.
- Technical activity will take place in groups and individually. Limit the time for custom production to keep students from spending too much time on a simple product. Have students work in one or two groups for the batch production.

Equipment/Supplies

1. 2 x 4s
2. Marbles
3. Screws
4. Poster board

Evaluation Key

1. Identify and list the three types of production organization.
   A. Batch
   B. Mass
   C. Continuous

2. Describe the differences between types of production.
   A. Number of products made
   B. How the products are made
   C. Cost of product

3. Describe the similarities between types of production.
   A. Use of equipment
   B. Fulfill a need or want
   C. Supported by a company

PRODUCTION ORGANIZATION

Study the three types of production—mass, batch, and custom—then produce the same product using two different methods and compare the differences.

Objectives

- To identify and list the three types of production organization
- To describe the differences between types of production
- To describe the similarities between types of production

Vocabulary/Concepts Reinforced

- Mass production
- Batch production
- Custom production

Equipment/Supplies

- 2 x 4s
- Marbles
- Screws
- Poster board

Introduction

There are three types of production line organization. Products are made in batch, mass, or continuous production runs. Batch production runs make large amounts of one type of product before switching to a different product to run. Continuous production is a production line that has an uninterrupted flow of products. This type of production run is heavily used in food and beverage production. Custom production is the making of one special product at a time—for example, retrofitting a jet or bus for some rich and famous person or making a piece of furniture or clothing.

Go to the library and do some further research on these types of manufacturing. Prepare a poster that compares the three types of production.

Batch produce 20 to 24 tic-tac-toe games and custom produce the same number (depending on how many students are in the class). Conduct an analysis of the final products and the processes used to produce those products.

Procedure

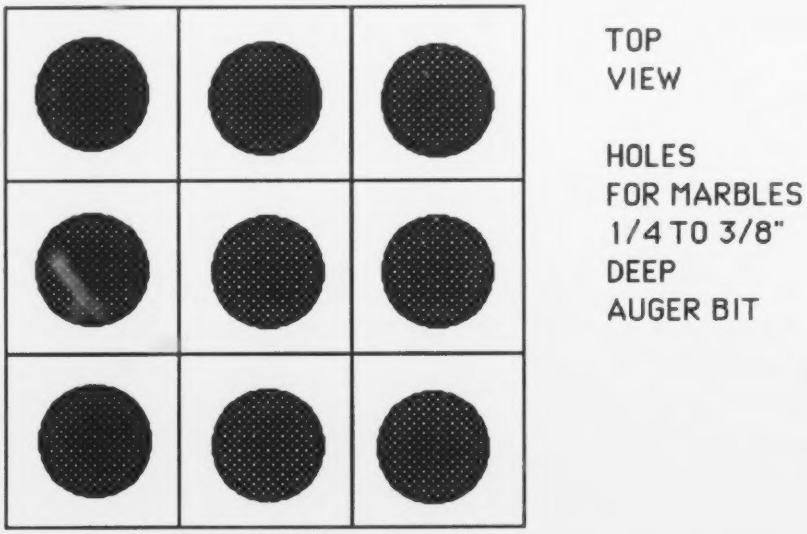
1. Research mass, batch, and custom productions; prepare a poster.
2. Conduct a batch production run producing tic-tac-toe games.
3. Conduct a custom production run producing the same number of games.
4. Compare the products and the processes.

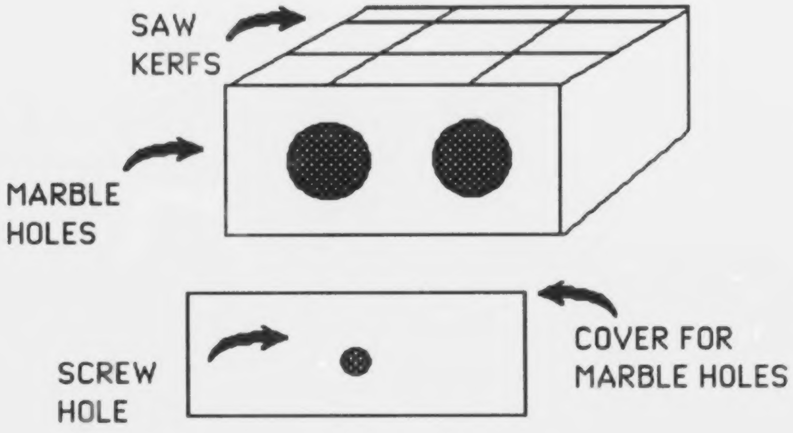
Evaluation

1. Identify and list the three types of production organization.
   A.
   B.
   C.

2. Describe the differences between types of production.
   A.
   B.
   C.

3. Describe the similarities between types of production.
   A.
   B.
   C.


TOP
VIEW
HOLES
FOR MARBLES
1/4 TO 3/8"
DEEP
AUGER BIT


SAW
KERFS
MARBLE
HOLES
SCREW
HOLE
COVER FOR
MARBLE HOLES

Support Materials

- Wright, Tom, and Tom Jensen. *Manufacturing: Material Processing, Management, Careers*. South Holland, Ill.: Goodheart-Willcox, Inc., 1976.

(3-4 WEEKS)

THE ENTERPRISE SYSTEM

Essential Elements: Common: 1A; 2A, B, D, F, G; 3A, C; 4E, F; 5G, H; 6A, B; 9A; 10C
Specific: 4, 12
TAAS Objectives: Math: O 3, 4; PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

Students will study the enterprise system by creating a company, producing a product, and analyzing the performance of their company.

Teaching Tips

1. Select a product that is simple to make; toy cars are one idea. See the book *Manufacturing* by Jim Fales (McKnight Publishing Co.) for other excellent ideas.
2. Select a community service organization with which you can develop a relationship over time. Try to identify other activities that your classes or Technology Student Association can become involved in. More than one organization can be contacted; or several different products can be made for one organization.
3. Set up the unit to take place near a holiday; Christmas and Easter are times when children would enjoy receiving a gift.
4. Try to get a local business involved. You might get them to donate the materials.

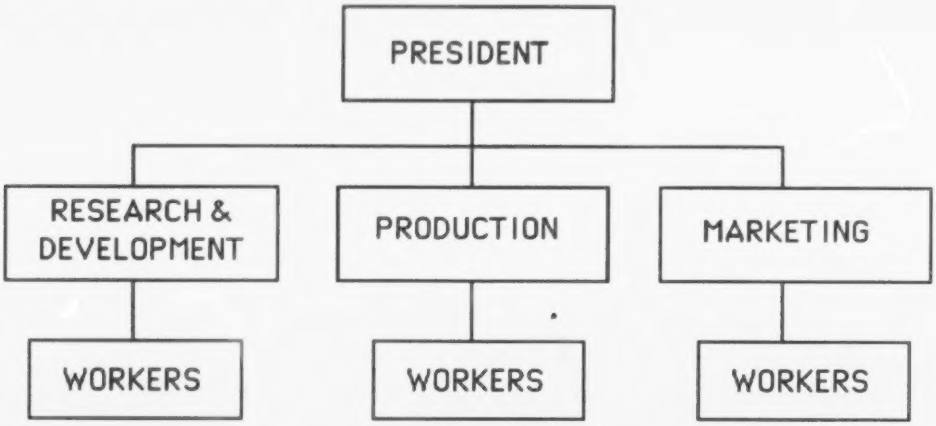
Instructional Strategy

1. This activity can be structured for several groups in one class or one production group per class. If more than one group is used in each class, the group needs to be of a large enough size to handle the different jobs that need to be done. If more than one class is participating in this activity, several different products can be made.
2. In forming the company, the teacher needs to provide guidance in the selection of company officers. The student who serves as president needs to have good organizational skills and the ability to work with most other students in the class.
3. This can be used as an introductory unit to manufacturing. In that case, the instructor needs to select the products and guide the process more closely. The products need to be simple to construct and the skill level fairly low. If this activity is used with more experienced students, the teacher can allow for more decision making by the students. The products made by a more experienced group can be more sophisticated and require a higher skill level.
4. Another dimension that can be studied is the involvement of corporations and industries in local communities. Students can study the types of activities these organizations get involved in and the reasons organizations invest in communities through service activities. You might consider using a guest speaker for this topic or working with the social studies teacher to introduce the concept of civic responsibility.
5. Invite the school newspaper and local newspaper to take pictures when the toy or product is delivered to the service organization or to the children. Have students interviewed for an article in the paper.
6. You could team teach this with a social studies teacher and examine the structure of companies in depth.

Evaluation Key

1. List three types of company ownership.
   A. Proprietorship
   B. Partnership
   C. Corporation

2. Identify the major parts of an organizational chart.


PRESIDENT
RESEARCH & DEVELOPMENT
PRODUCTION
MARKETING
WORKERS
WORKERS
WORKERS

3. List the three major areas of company activities.
   A. Research and Development
   B. Production
   C. Marketing

4. Define *quality control*.
   That part of the production process that assures that all products meet the standards established by the company.

5. Identify community service organizations.
   A. Lions Club
   B. Service League
   C. Kiwanis
   Jaycees
   Church groups
   Homeless organizations

THE ENTERPRISE SYSTEM

Study the enterprise system by creating a company, producing a product, and analyzing the performance of the company.

Objectives

- To list three types of company ownership
- To list the major parts of an organizational chart
- To list the three major areas of company activities
- To define *quality control*
- To identify community service organizations

Vocabulary/Concepts Reinforced

- Company
- Organizational chart
- Research and development
- Production
- Marketing
- Quality control
- Community
- Service organizations
- Prototype
- Jig
- Fixture

Equipment/Supplies

- Depends on the product selected

Introduction

Within your local community, many organizations exist to provide services to you and other community members. There may be a local Lions Club, for example. Lions Clubs are involved in many activities, including eye testing to identify sight problems. There might be a Junior League or Service League that raises money for college scholarships. Another organization might raise money or have clothing or food drives to help needy families. It is important to provide services to those in the community who are in need.

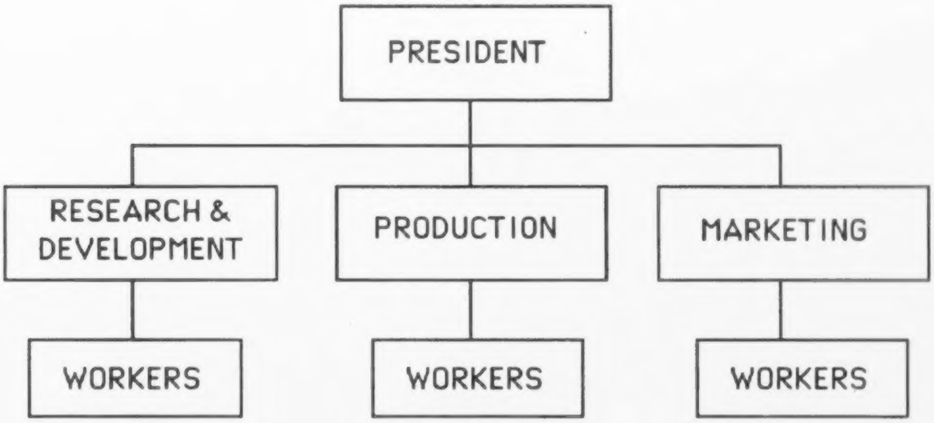
Contact the local Chamber of Commerce for a list of community service organizations in your area. Identify an organization that helps needy families or select a home for children. Identify a toy (or have your teacher suggest a product) that your class can mass produce through a company enterprise activity for this organization. Mass produce and donate the products to someone in need.

There are three types of companies that can be established. A *proprietorship* is a company that is wholly owned by one person. A *partnership* is owned by more than one person; it could be two or twenty people. A *corporation* is owned by stockholders. You should do some more research at this point to find out about these three types of companies. What types of companies exist in your community?

Are there proprietorships? partnerships? corporations? Are they manufacturing plants? Service oriented? Military operations? Food producers?

You should examine what impact these companies have had on your community. Do these companies provide many jobs? Have they helped the local economy? What would happen to your community if one of the major employers closed its doors? What impact would this have on your community, school, parents, or family? Companies or commodities can affect the economic health of a region or state. An example of a downturn was the drop in oil prices in the mid- to late 1980s and the effect it had on the Texas economy. People lost their jobs, their homes, their cars. Many times when people are affected by a downturn in the economy, community services are available to help them through the difficult time. This lesson focuses on using a company to help others.

Form a company with officers and set up a production run to mass produce your product. You will need to have a *research and development* program area, a *production* program area, and a *marketing* program area. The President oversees the operation of the company and coordinates the activities of the three program areas.



The research and development program area will be concerned with making a prototype of the product. A *prototype* is a sample of the finished product that can be used to determine any changes in design that need to be made. Flaws in the product can be identified. Is one part too weak? Should the product be finished with stain or paint? Are moving parts, such as wheels, secure?

The production program area will be concerned with the actual production of the product. Jigs and fixtures will need to be developed. *Jigs* secure the workpiece and guide the tools completing the work. *Fixtures* are attachments to machines that hold the workpiece in place for work to be done. The production area must determine what tasks must be completed and their sequence. The production area is also responsible for quality control. *Quality control* is that part of the production process that assures that all products meet the standards established by the company.

The marketing program area is responsible for promoting the product and the company. This area should also handle the design of a company logo. In this case, an article to the local or school newspaper about the production run might be appropriate. In an actual company, the marketing area would be responsible for making the products available to the consumer and persuading the consumer to purchase them.

Setting up a company and producing a product will help you to understand some of the processes in getting a product from raw materials onto the store shelf. Producing a product as a community service will help you to learn about your community and some of the organizations that exist to help people.

After your production run is complete, the enterprise will need to evaluate the manufacturing process. The group should respond to the following questions:

- What went well with the production run?
- What was the greatest achievement of each program area?
- Was the quality control process effective?
- What could have been done better in each program area?
- What would you do differently the next time?

Reflecting upon these questions will allow the group to determine the overall success of the enterprise. In the business world, success is usually determined by the profits made for the company and/or the stockholders. As this production run was to benefit children, evaluation of success should be based on meeting the objective: supplying toys or products for children who have none.

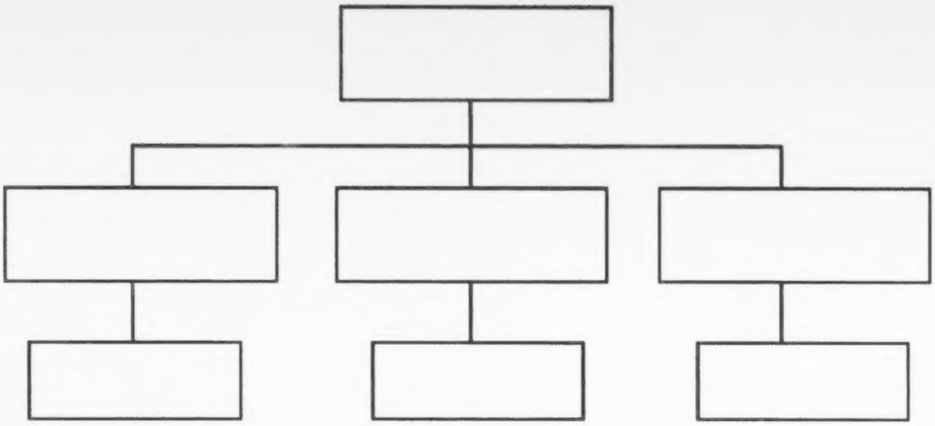
Procedure

1. Identify a product.
2. Identify a community service organization.
3. Organize a production company.
4. Produce the product.
5. Present the product to the service organization.
6. Disband the company and evaluate the process.

Evaluation

1. List three types of company ownership.
   A.
   B.
   C.

2. Identify the major parts of an organizational chart.



3. List the three major areas of company activities.
   A.
   B.
   C.

4. Define *quality control.*

5. Identify community service organizations.
   A.
   B.
   C.

Support Materials

- Chamber of Commerce materials
- Fales, Jim, et al. *Manufacturing*. Bloomington, Ill.: McKnight Publishing Co.
- Wright, Tom. *Manufacturing Processes*. South Holland, Ill.: Goodheart-Willcox Co., Inc., 1988.

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 5
(2 WEEKS)

MATERIAL TESTING

Essential Elements: Common: 2A, F; 4F; 6A; 9A, B; 10B, C
Specific: 5, 12
TAAS Objectives: Math: C 1, 2; O 1, 2; PS 2, 3
Reading: 1-6
Writing: 7

Activity Summary

In this activity, the students will test several materials used in production, learn to read micrometers and calipers, and become aware of career opportunities in the material testing field. After an overview, students will conduct experiments on different welds. Career information will be presented by the instructor or a guest lecturer from the material testing field.

Teaching Tips

1. Stress the accurate reading of micrometers and calipers. These skills lay the foundation for many activities in the production area.
2. Have sample welds prepared for the students as guides; or, if the students' skill level in welding is high enough, allow them to create welds of their own to test.

Instructional Strategy

- Introduce the material listed below. Stress accurate measurement with calipers and micrometers. Have the students work in groups to produce sample welds of different types using more than one welding method if possible. Have students measure welds. Conduct nondestructive tests on the welds. Have students prepare a report on their findings.

- Present information on welding.
  Survey types of welding processes for joining materials:
  1. Arc welding
  2. Resistance welding
  3. Flash welding
  4. Oxyfuel gas welding
  5. Solid state welding
  6. Electron beam welding
  7. Laser beam welding
  8. Brazing
  9. Soldering
  10. Adhesive bonding
  11. Welding plastics

All welded structures serve some type of function. The welded joints that make up these structures must be able to fulfill their function. Tests are conducted to ascertain the integrity of sample welds.

- Introduce sources of welding energy:
  1. Electrical
  2. Chemical
  3. Optical
  4. Mechanical

5. Solid state

- Define *weld*.
  "Welding is the most effective method of joining materials. . . .The term *weld* is, unfortunately, ambiguous because it is used in so many ways. Technically, it refers to the area of coalescence produced by the welding process. In describing a weld, it is helpful to be more specific, and thus the term used here, and the one most often meant when a weld is mentioned, is a welded joint, which includes not only the melted or coalesced zone but also the region around it. Another term often used is *weldment*. This term normally means an assembly, large or small, which contains one or more welded joints." (From *Welding Handbook,* 7th ed., Vol. 1. American Welding Society, 1982, p. 122.)

- Define *weldability*.
  "Weldability is the capacity of a metal or combination of metals to be welded under fabrication conditions into a specific, suitably designed structure, and to perform satisfactorily in the intended service." (From same source cited above, p. 137.)

- Introduce testing to evaluate welded joints.

Destructive Testing

1. Tensile testing for strength and ductility
2. Fracture toughness
3. Fatigue of welded joints
4. Corrosion factors in welded joints
5. Creep-rupture testing
6. Compression testing

Destructive testing destroys the sample weld during the testing process. Conditions for use of the weld can be simulated and provide useful information during the testing process. However, separate tests, such as environmental or material tests, may need to be conducted for each different factor. The objects used in the tests must be similar to those actually to be used in the product. As nondestructive testing is a less expensive process, this unit will focus on this process.

Nondestructive Testing

1. Liquid penetrant
2. Filtered particle
3. Electronic inspection
4. Fluoroscopy and x-ray imaging
5. Discontinuities in welds

Nondestructive testing can provide assurances about product reliability, accident prevention, and increased profits. Manufacturing and production costs can be greatly reduced through nondestructive testing. The nature of the transportation industry, for example, has changed significantly with a major increase in the use and speed of all types of vehicles. As velocity increases, so does the stress on the parts comprising the vehicle. Material fatigue and safety factors must be considered when designing products and determining which parts will use welds as fasteners. Low cost makes nondestructive testing a viable option for industry today. Some of the testing processes can even be automated.

Of all nondestructive tests, the liquid penetrant test is the easiest to administer and the most cost-effective. This method relies on the liquid seeping into any defects in the weld. When using this test, one would be looking for surface cracks, porous welds, or lack of bonding between the weld and the surface material.

While liquid penetrant tests of products may differ, the basic process is as follows:

1. Apply penetrant to the surface; allow to remain for the specified time.
2. Remove excess penetrant.
3. Apply a developer.
4. Inspect the weld.
5. Measure.

   A. **Calipers**
   Outside calipers are used to measure the outside diameter or width of an object within 1/64 inch. Use the calipers so that they are square with the piece of work. Move the caliper legs together until they touch the stock. Measure the distance in between with a steel ruler. Inside calipers can be used to measure the inside diameter of cylindrical workpieces. Using inside calipers is similar to using outside calipers.

   B. **Micrometers** (also called **micrometer calipers**)
   Micrometers allow for measurement within thousandths and ten-thousandths of an inch. The premise for measurement is based on 40 screw threads to the inch so that each complete turn will advance the spindle 1/40 inch or 0.025 inch. A micrometer with a one-inch capacity has the sleeve marked with 40 lines to the inch which correspond with the number of threads on the spindle. Every fourth line is longer to represent 1/10 inch. The beveled edge of the thimble is numbered from 0 to 25. With the caliper closed, only the 0 is visible on the sleeve. Each complete revolution (from 0 to 0) advances or retracts the spindle 1/40 inch. Calipers must be kept very clean so that they can measure accurately.

- Careers in material testing might include:
  1. Designer and stress engineer
  2. Materials or process engineer
  3. Nondestructive test engineer
  4. Technician
  5. Inspector
  6. Welding engineer
  7. Researcher

Equipment/Supplies
- Micrometers
- Calipers
- Dry magnetic particle tester (optional)
- $550 for "yoke" assembly (will last many years)
- $20 for powder (consumable supply)
- Penetrant die testers (liquid)
- $21 total for 1 can of cleaner ($7), 1 can of dye ($7), 1 can of developer ($7)

Evaluation Key
1. Written report
2. Quiz answers

MATERIAL TESTING

Test several materials used in production, learn to read micrometers and calipers, and become aware of career opportunities in the material testing field.

Objectives

- To accurately read a micrometer
- To accurately read a pair of calipers
- To list four types of destructive testing
- To list four careers in the material testing field
- To work safely in the laboratory
- To determine strength of production materials
- To determine strength of welds

Vocabulary/Concepts Reinforced

- Micrometer
- Caliper
- Destructive testing
- Nondestructive testing

Equipment/Supplies

- Welding supplies
- Metal, preferably a low-carbon alloy
- Testing supplies
- Calipers
- Micrometers

Introduction

We take for granted many products in our world. Automobiles are one prime example. Out of the millions of cars on the roads today, look how few fall apart. Most cars are welded together. One automaker has a robot that can produce 400 welds in 51 seconds! What produces such faith in these welds? When welds are used to hold parts together, they are tested to assure the integrity of the weld.

This unit will help you to explore the testing and measurement of welds. You will use two new measuring devices a micrometer and a caliper. You will also have the opportunity to try nondestructive testing.

Procedure

1. Produce welds as directed by instructor.
2. Listen to lecture on testing.
3. Observe teacher demonstration on testing welds.
4. Work in small groups (of 2 or 3) to test welds.
5. Write results in report format.
6. Explore careers in testing.

Evaluation

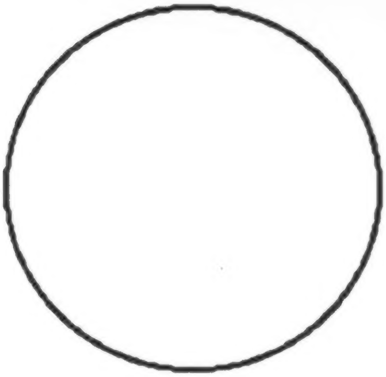
Grade on written report

1. Use calipers to measure the following lengths and internal circumferences:

A. ____

B. ____________________________________

C.



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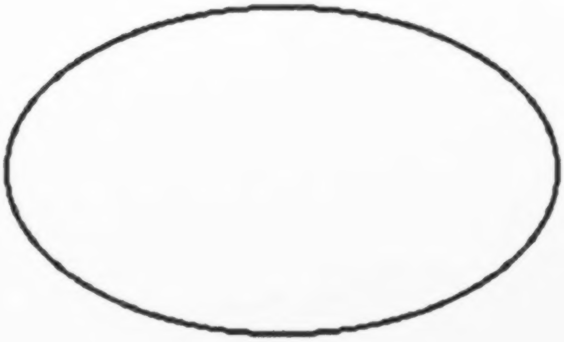


2. Use micrometers to measure three samples provided by the instructor.

A. ______________________

B. _______________________

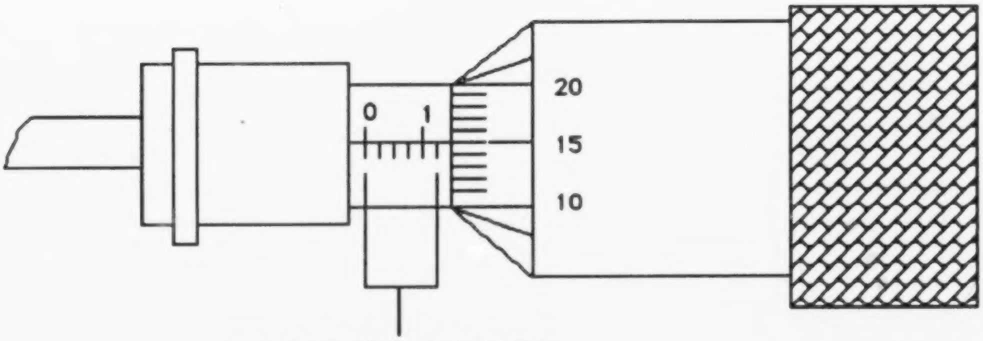
C. ______________________

3. List two advantages of nondestructive testing.

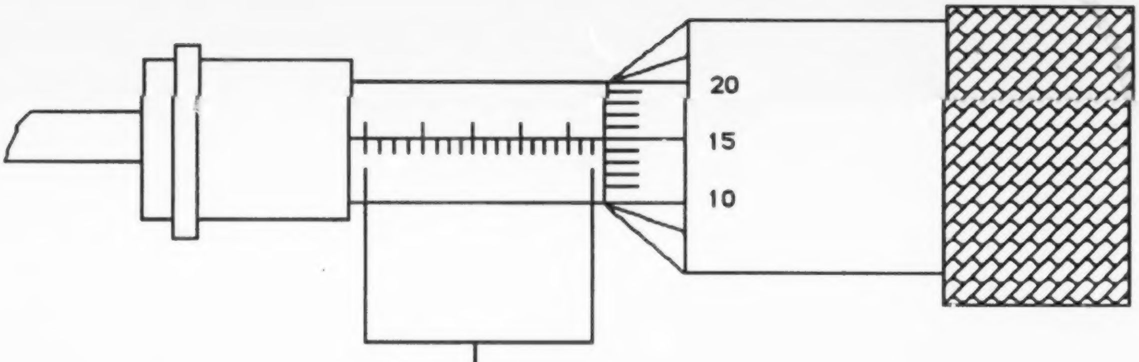
4. List two careers in the material testing field and the educational requirements for each.

Support Materials

- Teacher resources on welding
- *Nondestructive Testing Handbook*. Edited by R.C. McMaster. Vols. 1 and 2. American Society for Nondestructive Testing, 1959.
- *Welding Handbooks*. 7th ed. Vols. 1, 2, and 4. Miami: American Welding Society, 1982.



0.125 + 0.015 = 0.140 TOTAL



0.450 + 0.015 = 0.465

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 6
(2-3 WEEKS)

STRUCTURE CLASSIFICATION

Essential Elements: Common: 1A, D; 2C-F, H, I; 3B; 4C; 5B; 6A-C; 7A-D; 8D-F; 9A-D; 10A, C
Specific: 3

TAAS Objectives: Math: C 3; O 1, 2; PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

Students will study the different types of structures and their purposes. They will then work in teams to build models of buildings to solve design problems.

Teaching Tips

1. If possible, find a wheelchair for students to use during class. Have students try to maneuver around the lab and use some of the equipment from the wheelchair.
2. You might do a competition between your classes if you teach the same class more than once during the day. Have different projects within each class period.

Instructional Strategy

- This can provide a good outline for lecture and discussion. Students can provide many ideas for discussion through a brainstorming session to generate the different structure types. They can also brainstorm to explain the functions of these structures.

- If a facility is being built near your school, have the students document the work over a period of time with photographs. You might be able to get the director of the site to come talk to your class.

- Have students work in groups to design and build models to solve the following problems. Models should be built mostly from scrap materials. You can use foam board for much of the outsides of the buildings.

- **Problem #1:** Design and build a combination school and community center. It will include a shared library and a shared sports facility. The community center should also house five shops: a small grocery, a dry cleaners, a branch for a bank, a small post office, and a videotape rental store. The school should have wings or areas for the following: (1) science, math, and technology; (2) humanities (English, the arts, foreign language); (3) a computer laboratory; (4) a gymnasium (to be used by the school during the day and community during the evening); (5) a library (like the gymnasium, to be used jointly); (6) miscellaneous (for any areas overlooked); and administration. The building can be no more than two stories. Adequate parking should be planned.

- **Problem #2:** Design a combination indoor sports facility and shopping mall. The two functions should overlap wherever possible. The sports facility should have seating for 40-50,000 and the mall should have 45-50 stores, and a food hall with 15 fast-food places and restaurants (eating area). The sports facility will house musical groups for concerts and conventions held by professional groups.

Equipment/Supplies

1. Scrap wood and metal
2. Foam board sheets (foam sandwiched between cardboard)
3. Pictures of local structures (have some of each type)

Evaluation Key

1. List six different types of structures and their major functions.
   - A. Houses; shelter for families
   - B. Churches; places for spiritual development
   - C. Schools; places for learning
   - D. Shopping malls; places to buy goods and services
   - E. Airports; places to travel to and from
   - F. Sports facilities; places to be entertained

2. Explain why facilities should be accessible to physically handicapped individuals.
   These individuals should have the same right to access as people who are not handicapped. They should not be restricted from participation just because the facility planners weren't careful.

3. Sketch a design for a multipurpose house: two families of four each would live in adjoining, but separate quarters, and a small retail business would be run from one portion of the building. Remember to plan plenty of parking and facilities that are accessible to physically handicapped individuals.

   Use your own discretion to evaluate answers to this question.

STRUCTURE CLASSIFICATION

Study the different types of structures and their purposes, then work in teams to build models of buildings to solve design problems.

Objectives

- To identify types of structures
- To consider environmental concerns related to building structures
- To identify design considerations
- To identify structures that are not properly designed for physically handicapped individuals

Vocabulary/Concepts Reinforced

- Structure
- Environment
- Physical handicaps
- Building specifications

Equipment/Supplies

- Scrap materials: wood, plastic, metal
- Foam board sheets (foam sandwiched between cardboard)
- Pictures of local structures (have some of each type)

Introduction

Technology is altering the ways in which structures are built. What are the different types of structures?

Houses
Office buildings
Sports arenas
Churches, synagogues
Shopping centers (strip malls, indoor malls)
Museums, exhibit halls
Airports, train stations, ports for ships
Utility services centers (telephone, gas, electricity, etc.)
Dams
Bridges
Highways

What are the functions of each of these structures? Some are used for shelter, for work, for leisure, for support services, for transportation. Did we forget one? School buildings! They are used for preparing students for the world at large through the learning process.

People are in and out of structures all day long and probably don't think much about them. What are basic requirements for a structure? A floor, walls, ceiling. Anything else? Plumbing facilities for bathrooms, kitchens, laundry facilities. More? Electrical wiring for lighting and appliances. What else? People: people need to be able to move about the structure, especially if it is designed for large numbers of people. What if the hallways in your school were as narrow as the hallways in your home? Major traffic jams would occur between classes! How about going to a professional football or basketball game? Thousands of people attend these events. What if these structures had the same number of bathrooms as you have in your house? Very long lines would mean people would miss the entire game waiting for their turn. Structural designers have many people-oriented design concerns.

Other design concerns would include specific building codes within a city or geographic region, building height, building site, access for physically handicapped individuals, and traffic patterns. Building codes exist to provide guarantees that minimum standards for lighting, plumbing facilities, and building safety are met. The height of the building is important: will it need to withstand earthquakes (like those buildings built in San Francisco and Tokyo, Japan) or high winds? Many tall buildings, like the Sears Tower in Chicago, have mechanisms to correct for wind pressure. On a very windy day, you can feel the building move when you are up on the observation deck!

The building site is important as well. Down in southeast Texas, the water table is very high. You would not want to build a home with a basement there—it would be flooded most of the time. Questions asked by building designers would include: what is the content of the ground matter (rocky, swampy, sandy, clay)? how tall of a building and how much will it weigh? how deep do building supports need to be driven into the earth? how much settlement might occur and will it occur unevenly? Traffic patterns are important to consider when designing a building. Car and delivery truck traffic patterns are important. Where should cars enter the parking and drop-off area? Where should deliveries be made? Should they have separate entrances? What traffic patterns does your school have? Are there certain areas for teacher parking, student parking, bus loading and unloading, and visitor parking?

When designing a building, one must also consider the number of users and their traffic patterns. This is where the width of hallways or walkways become important. Malls have open walkway areas because the shopper should be able to see as many stores as possible from one point. If the shopper does not see a lot of stores, they may not be inclined to look for more stores or think that a certain store is in the mall. Schools have long halls with lockers built in as the easiest way to provide students with a private storage area for books and coats. Houses are broken up into living spaces. Bedrooms are usually separated from 'noisy' areas such as a family room or the kitchen. The kitchen is usually near the dining room or other eating area for convenience in serving food. These are some of the many important considerations that builders must be aware of.

Federal legislation has helped to support the development of buildings that are accessible for physically handicapped individuals. The physically handicapped have the same desires that the non-physically handicapped have. They like to live independently. They like to be able to earn a living and care for themselves. More and more building designers are including the necessary adjustments in their designs so that physically handicapped individuals can negotiate through buildings.

Having to negotiate a building in a wheelchair can be a difficult proposition. Doors are sometimes not wide enough to accommodate a wheelchair. Bathroom stalls have to be modified to be wider and have hand rails to assist physically handicapped individuals. What about buildings with attractive front entrances with three to twenty steps leading to the doors? In a wheelchair these would be impossible to enter. And speaking of traffic patterns, what about people who are not handicapped that park in those reserved spots? Many vehicles have been modified so that physically handicapped individuals can drive them. These vehicles need wide spaces so that the wheelchair can be wheeled into the vehicle. Another type of physically handicapped individual is the visually impaired. Many elevators have Braille numbers next to the buttons so that visually impaired people can make use of the facilities.

Technology has brought about many changes in services available to users of buildings. One example is that of the "smart house." "Smart houses" currently are being built that have a wiring system that combines electricity wires, cable TV wires, telephone wires, and stereo speaker wires all in one. Any appliance can be plugged into any room. Security systems are also a part of this "smart" system. The system can be programmed to turn appliances on or off; commands can be sent via a button, a switch, a built-in microphone, a telephone, a video touch screen, or computer terminal. The National Association of Home Builders has predicted that during the next two years, 5,000 of these homes will be built. The technology to alter current homes to have this type of wiring will be available by 1994 (*Good Housekeeping*, January 1990, p. 157).

Procedure

1. Study different types of buildings.
2. Work in groups to solve design problems.
3. Build model of building.
4. Write report and present building to prospective financiers.

Evaluation

1. List six different types of structures and their major functions.
   A.

   B.

   C.

   D.

   E.

   F.

2. Explain why facilities should be accessible to physically handicapped individuals.

3. Sketch a design for a multipurpose house: two families of four each would live in adjoining, but separate quarters, and a small retail business would be run from one portion of the facility. Remember to plan plenty of parking and facilities that are accessible to physically handicapped individuals.

Support Materials

- David McCauley, *The Way Things Work.*
- David McCauley, *Underground.*

INSTRUCTOR'S RESOURCE SHEET 7
(2 WEEKS)

COMPANY MANAGEMENT: CONSTRUCTION AND MANUFACTURING

Essential Elements: Common: 1A, D; 2C-F, H, I; 3B; 4C; 5B; 6A-C; 7A-D; 8D-F; 9A-D; 10A, C
Specific: 3

TAAS Objectives: Math: C 3; O 1, 2; PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

Students will compare the management activities of construction and manufacturing companies. They will also explore career opportunities in both types of companies.

Teaching Tips

1. Identify several people within the community who would be willing to come and talk to your classes. Try to have one person from construction and one from manufacturing for each class. Have a list of questions that you would like the visitors to respond to. Prepare the guests for the visit ahead of time—don't surprise them.

Instructional Strategy

- Go over background material.
- Have students conduct research in two groups, one for construction and one for manufacturing.
- Have each group make the appropriate posters on (1) organizational structure, (2) duties of company managers, and (3) careers.

Construction	**Manufacturing**
Management activities	Management activities
Similarity to manufacturing	Similarity to construction
Differences from manufacturing	Differences from construction
Careers	Careers

- When students present what they have discovered through research and the class has a discussion, make sure that the following information is covered, if it is not brought to light by the students: (1) three management activities for manufacturing and three for construction; (2) two similarities and two differences between manufacturing and construction; and (3) six jobs in these two areas of production.

As each of these points is brought up, discuss it in as much detail as possible. For example, when discussing the differences between construction and manufacturing, encourage further detail on the product can be discussed in terms of differences in size, use, consumer, cost, durability, regulations, etc. If at all possible, arrange for a field trip to a construction site and a manufacturing plant so students can see the differences in the worksites. If that is not possible, try for a filmstrip or movie; maybe a plant will let you videotape a tour. Discuss how construction changes the site itself; in contrast, while the internal manufacturing plant itself might be rearranged for different products to be made, the plant will not change much.

Equipment/Supplies

1. Library resources
2. Stationery
3. Poster board

Evaluation Key

1. List three management activities for manufacturing.
   A. Product development
   B. Tooling up the line for production
   C. Training workers to do specific job

2. List three management activities for construction.
   A. Site selection
   B. Development of individual building plans
   C. Organizing subcontractors

3. Identify two similarities between construction and manufacturing.
   A. Tools are used to produce product
   B. Process model applies to both

4. Identify two differences between construction and manufacturing.
   A. Product
   B. Site where work takes place

5. List six jobs related to manufacturing and/or construction.
   A. Company president
   B. Project manager
   C. Production manager
   D. Budget controller
   E. Worker
   F. Research and development manager

COMPANY MANAGEMENT: CONSTRUCTION AND MANUFACTURING

Compare the management activities of construction and manufacturing companies and explore career opportunities in both types of companies.

Objectives

- To list management activities for manufacturing
- To list management activities for construction
- To identify similarities between management activities
- To identify differences between management activities
- To list six jobs related to manufacturing and/or construction

Vocabulary/Concepts Reinforced

- Management
- Construction
- Manufacturing
- Organizational chart

Equipment/Supplies

- Library resources
- Stationery
- Poster board

Introduction

Organizational charts for both construction and manufacturing companies are similar. Each company will have a different chart based on its individual structure. Larger companies will have more people to handle the different responsibilities. In a small operation, a few people will handle multiple duties.

Organizational Chart

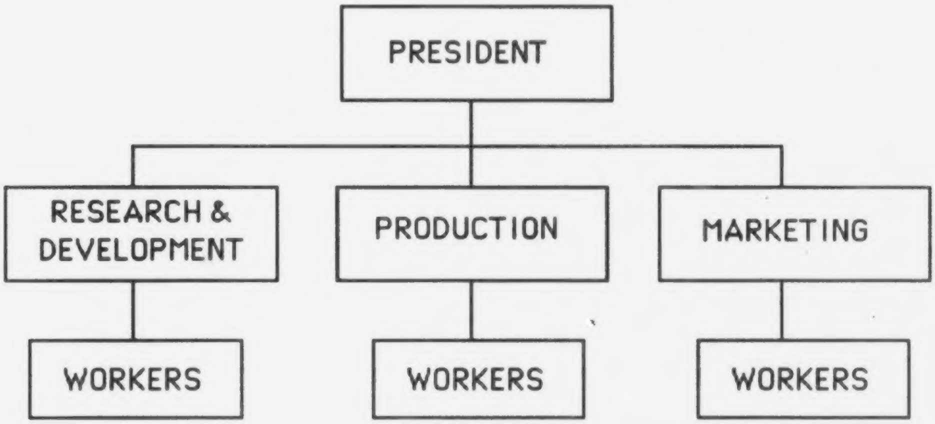
Construction

- Owner
- Architect
- Builder/Construction manager
  - General manager
  - Contract manager
  - Operations manager
  - Project executive
  - Estimator
  - Programmer
  - Engineer
  - Purchasing agent
  - Project manager
  - Accountant
    - Workers

Manufacturing

- Owner
- President
- Vice-presidents for
  - R&D
  - Marketing
  - Finance
  - Production
    - Engineers/Designers
    - Plant manager
    - Supervisors
      - Workers

An example organizational chart looks like this (also covered in Activity 4):



Each company's organizational chart will vary depending upon how many layers (steps between the workers and the president) exist.

Split the class into two groups. One group will focus on manufacturing, one on construction. Each group will research its company type, identify a local company, and write to that company for information related to:

- Organizational structure
- Duties of company managers
- Careers

Each group will develop three posters, one for each of the three topics listed above. When these are completed, the class will compare the two systems.

Procedure

1. Study manufacturing and construction management.
2. Write to a company for more information.
3. Graphically represent your information on posters.
4. Compare manufacturing and construction management practices.

Evaluation

1. List three management activities for manufacturing.
   A.

   B.

   C.

2. List three management activities for construction.
   A.

   B.

   C.

3. Identify two similarities between construction and manufacturing.
   A.

   B.

4. Identify two differences between construction and manufacturing.
   A.

   B.

5. List six jobs related to manufacturing and/or construction.
   A.

   B.

   C.

   D.

   E.

   F.

Support Materials

- Batty, J. *Industrial Administration and Management*. Macdonald and Evans, 1969.
- Bush, Vincent G. *Construction Management*. Reston, Va.: Reston Publishing Co., Inc., 1973.
- Cusman, Robert F., and William J. Palmer. *Businessman's Guide to Construction*. Homewood, Ill.: Dow Jones-Irwin, 1980.
- Sandman, William E., and John P. Hayes. *How to Win Productivity in Management*. New York: American Management Assn., Inc., 1982.

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 8
(2-4 WEEKS)

PRODUCT DEVELOPMENT

Essential Elements: Common: 1A, D; 2C-F, H, I; 3B; 4C; 5B; 6A-C; 7A-D; 8D-F; 9A-D; 10A, C
Specific: 3
TAAS Objectives: Math: C 3; O 1, 2; PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

The students will create a new product and build a prototype. They will also study the development of a product from idea to production.

Teaching Tips

1. Several national competitions exist that you could involve the students in:
   A. Junior Engineering & Technical Society (JETS). Teams Tests ($15.00 per set; JT-04 order number) and Teams National Group Tests ($50.00 per set; JT-05 order number) can be obtained by writing to JETS, 1420 King Street, Suite 405, Alexandria, VA 22314. JETS has chapter affiliations similar to Technology Student Association. Order "Jt-02 JETS Program Aids" ($7.50); has suggestions for design competitions, problem-solving competitions, and mini-projects. Some materials are free.
   B. The Duracell NSTA (National Science Teachers Association) Scholarship Competition. Awards 41 scholarships and prizes. Entries must be student-designed and built, and powered by Duracell batteries. Entries must include a two-page written essay, wiring diagram, photographs, and official entry forms. For more information, contact the National Science Teachers Association (it administers the competition), 1742 Connecticut Avenue, NW, Washington, DC 20009-1171.
2. Have students bring in articles from magazines or newspapers on new products and product development. Display them on a bulletin board. Identify how many new products are announced during the course of the unit.

Instructional Strategy

- Have books available on product development from the school or town library.
- Have answers for questions asked in student portion of the text ready, but let the students brainstorm for ideas; don't spoon-feed them all of the information.
  1. What is a product life cycle?
     The path a product follows from introduction, through accelerating revenue growth, constant growth in sales, decreasing sales, and a leveling off of sales. From that point products can continue to sell (Ovaltine), or drop out of the marketplace (Pet Rocks).
  2. What is the product life cycle of electronic equipment?
     about six months
  3. What is the product life cycle for new foods?
     about six months
  4. What is the product life for games and toys?
     for most, from Christmas to Christmas; for electronic toys, a few months
  5. When was the game Monopoly invented?
     1930s

6. When was Shredded Wheat cereal introduced?
   1893

- Use the Duracell battery contest for parameters for the product development activity. Divide the students into groups of 3 to 5 people and have them develop a product.

Equipment/Supplies

1. Scrap materials: wood, plastic, metal
2. Electrical wiring
3. Batteries

Evaluation Key

1. List and describe the four positions found in a large company that will be involved in product development.
   - A. The research and development (R&D) scientist develops and works on a new idea or product concept to determine feasibility of development.
   - B. The production manager is responsible for producing the most products in the shortest time for the least amount of money possible.
   - C. The sales manager goes out and gets orders for the product.
   - D. The controller watches the financial portion of the product development team.
2. List three new products that have been introduced within the last 12 months.
   Teenage Mutant Ninja Turtles
   McDonald's McRib Sandwich
   McDonald's Cheddar Melt Sandwich
   Etc.

PRODUCT DEVELOPMENT

Create a new product and build a prototype in order to study the development of a product from idea to production.

Objectives

- To list and describe the four positions found in a large company that will be involved in product development
- To list three new products that have been introduced within the last twelve months

Vocabulary/Concepts Reinforced

- Product life cycle
- Product development
- Research & development scientist
- Production manager
- Sales manager
- Controller

Equipment/Supplies

- Scrap materials: wood, plastic, metal
- Electrical wiring
- Batteries

Introduction

Make three lists on the chalkboard. List, in three separate columns, your classmates' favorite toys/games, foods, clothing (i.e., special type of gym shoe, style of coat, designer name, etc.). Looking at the lists, decide how long have those products been around. How would you go about finding out about those products? How do new products come into being? In this unit, we'll explore the creation of new products, and determine how they get to the stores.

Do some research in the library, or with books that your teacher provides. Answer the following questions:

- What is a product life cycle?
- What is the product life cycle of electronic equipment?
- What is the product life cycle for new foods?
- What is the product life for games and toys?
- When was the game Monopoly invented?
- When was Shredded Wheat cereal introduced?

Other questions to consider would be: How many new foods has McDonald's introduced in the last year? How many new Saturday morning cartoons are there this year? How long have Mutant Ninja Turtles been around? New products show up all the time, yet the former president of 3M (they make Scotch™ tape and Post-it™ notes) has said that "out of every 100 new-product concepts, 33 will prove technically feasible; and of these, 3 will become commercially successful in the market." That is a 3 percent success rate in product development! What type of grade would you get in a class where you were correct only 3 percent of the time?!

General Foods in a typical ten-year period will have 600 ideas, 30 successful new products, and have spent $230 million in product development!

In large companies several positions that people fill who are helpful in getting products to consumers. The research and development (R&D) scientist develops and works on a new idea or product concept to determine feasibility of development. The production manager is responsible for producing the most products in the shortest time for the least amount of money possible. The sales manager goes out and gets orders for the product. The controller watches the financial portion of the product development team. These people all have to work together to come up with products that are winners.

You will work in teams of 3 to 5 people and each group will develop a new product based on criteria that your teacher will provide. Have fun!

Procedure

1. Study product development.
2. Research certain products to find out about their development.
3. Work in groups to develop new products using batteries as the power source.

Evaluation

1. List and describe the four positions found in a large company that will be involved in product development.
   A.

   B.

   C.

   D.

2. List three new products that have been introduced within the last 12 months.
   A.

   B.

   C.

Support Materials

- Buggie, Frederick D. *New Product Development Strategies*. New York: American Management Assn., Inc., 1981.
- Frand, Erwin A. *The Art of Product Development*. Homewood, Ill.: Dow Jones-Irwin, 1989.
- Hanan, Mack. *Re-Competitive Strategies: How to Regain Growth Profits for Mature Businesses*. New York: American Management Assn., Inc., 1986.

(2 WEEKS)

SIMULATION OF AUTOMATION

Essential Elements: Common: 1A, D; 2C-F, H, I; 3B; 4C; 5B; 6A-C; 7A-D; 8D-F; 9A-D; 10A, C
Specific: 3

TAAS Objectives: Math: C 3; O 1, 2; PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

Students will learn the basics about robots and some of the social issues related to using robots in the work force. A small production activity will be used to simulate automation.

Teaching Tips

1. If you have a robot in your laboratory, this might serve as an introductory unit. As you work through the production activity, the robot can be used as material handling or work accessory.
2. If you have a robot in your classroom, you could do an introductory demonstration. Have a student pick an eraser up and move it back and forth between two marked spots. Increase the speed at which the student performs the activity. See how long the student can continue to accurately perform the task. Have your robot preprogrammed to perform the task. This should demonstrate that robots can perform tasks accurately over time.

Instructional Strategy

- This portion should be lecture and discussion. Have the students brainstorm for ideas at the places in the text where questions are asked.

Role-playing Section

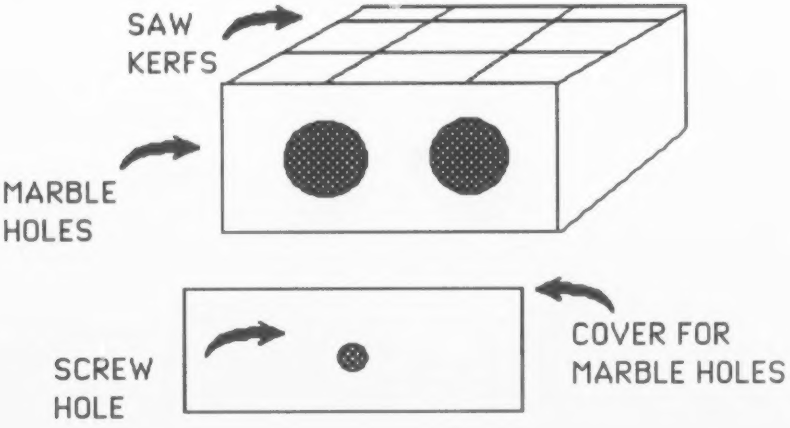
- Tell the class that you are their supervisor. You all work in an auto plant, making cars. Set the students up with the following information:
  Wages: $19.00 per hour
  Benefits: health, sick leave, reimbursement for schooling
  Personal: some are married, some divorced; ages range from 25-50; many have children

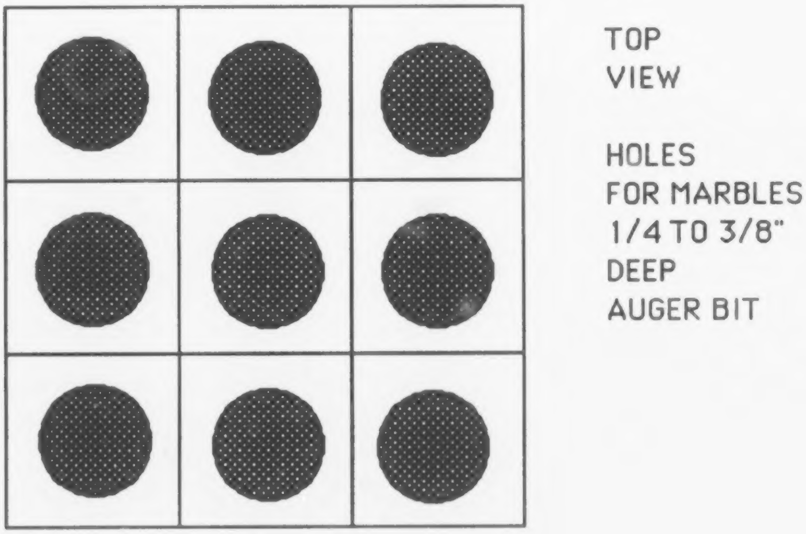
- You can add to the list. After providing the preliminary information, split the class in half and pick one half to work with. Tell this group that they are being laid off and being replaced by robots. Start with the first person in the half you selected. Ask this person what she/he is going to do now. Don't give students too much time to think. Go to the next student and ask him/her the same question. The first several students may not have answers. As you progress through this portion of the class, it is hoped that students will eventually begin to provide responses such as "I'm going to learn to fix robots," "I'm going to go to college," etc. This exercise can help to highlight a social aspect of the use of robotics in production.

Production Activity Section

- Have the students prepare to conduct a production run. The product will be tic-tac-toe games made from 2 x 4s (just as in Activity 3, but this time with automation). Their job is to automate part of the production activity (e.g., the drill press operation) and at least some of the material handling activities.

- The game has saw kerfs cut across the top in two directions to demark the playing area. Holes are drilled in the 9 squares that result (see drawing). Holes are also drilled into the end grain of one side. Another piece of 2 x 4 is cut, drilled, and screwed on to hold the marbles in place. The game is simple so that students can focus on the automation.


SAW
KERFS
MARBLE
HOLES
SCREW
HOLE
COVER FOR
MARBLE HOLES


TOP
VIEW
HOLES
FOR MARBLES
1/4 TO 3/8"
DEEP
AUGER BIT

Equipment/Supplies

1. 2 x 4 stock
2. Marbles
3. Finish

Evaluation Key

1. Define:

   automation—the mechanical control of production processes by electronic apparatus
   simulation—an activity that allows you to experience an event without actually having the event take place
   robotics—mechanisms that mimic the human arm

2. Identify social concerns related to automation in industry.

   People might lose their jobs; unemployment might rise.

3. List the types of movements robot arms can make.
   - A. move in rotate
   - B. move outpitch
   - C. up
   - D. down
   - E. tilt
   - F. swivel

4. List the methods by which robots can be programmed.
   - A. computer programs
   - B. teach pendants
   - C. manual manipulation of a teaching arm used by the programmer to actually move through the same motions the robot should perform

SIMULATION OF AUTOMATION

Learn the basics about robots and some of the social issues related to using robots in the work force.

Objectives

- To define *automation, simulation, robotics*
- To identify social concerns related to automation in industry
- To list the types of movements robot arms can make
- To list the methods by which robots can be programmed
- To simulate automation in a production activity

Vocabulary/Concepts Reinforced

- Automation
- Simulation
- Robotics
- Cybernetics
- Layoffs

Equipment/Supplies

- 2 x 4 stock
- Marbles
- Finish

Introduction

Many types of industries use automation as a process to aid in the manufacture of goods. Automation is the mechanical control of production processes by electronic apparatus. Honda of America Manufacturing, which has an automobile plant in Marysville, Ohio, has automated several processes in its production plant. One automated process is the joining together of the chassis, side panels, and roof of the car. One machine completes this task by doing 400 spot welds in 51 seconds! Another process, automated by Honda at the workers' request, is the assembly of the window handles. The workers told management that it was the most boring job in the whole manufacturing plant, and asked if it was possible to automate the process. A team of Honda engineers developed a robot to perform the task and the workers received new job assignments; the workers did not lose their jobs to robots.

A major concern of many workers is that robots will replace them in their jobs. In some cases this is true. Many times jobs that are boring or dangerous can be automated. The workers can be trained in other tasks at the manufacturing plant. Why do you think that workers would not want to learn a new job? Or stop a job that is unsafe, boring, or dangerous? Discuss this with your class. Often, fear of the unknown or fear of something new can keep people from accepting change in the work environment.

What do you think are the reasons for companies wanting to automate the work process? Some of these are:

1. Increased productivity
2. High cost of labor
3. Labor shortages
4. Trend of labor toward the service sector
5. Safety
6. High cost of raw materials
7. Improved product quality
8. Reduced manufacturing lead time
9. Reduction of in-process inventory

These factors can make automation an attractive proposition for manufacturers. There are a few reasons why a company might not want to automate. They might include, but are not limited to reducing the size of the labor force, unemployment will escalate, and changing the nature of work and how workers perceive what they do on the job.

The main way that companies automate is with robots. What is a robot? Images of R2-D2 and C3PO from *Star Wars* come to mind. Most industrial robots are mechanisms that mimic the human arm. Another major use of industrial robots is material handling by either an automated guided vehicle or a workpart handling system. There are two basic parts: the mechanical component and the control component. The mechanical component usually includes some sort of a base from which the robot operates; an arm that can move in, out, up, down, tilt, swivel, rotate, or pitch; some type of gripper to hold the work; and the driver element. Robots can be either fixed in place or mobile. The control component directs the robot to perform the desired functions. The robot can be programmed through computer programs, teach pendants, or manual manipulation of a teaching arm used by the programmer to actually move through the same motions the robot should perform.

Procedure

1. Learn introductory material.
2. Participate in role-playing.
3. Design ways to automate the production of the game.

Evaluation

1. Define:
   automation—

   simulation—

   robotics—

2. Identify social concerns related to automation in industry.

3. List the types of movements robot arms can make.
   A.
   B.
   C.

D.
E.
F.

4. List the methods by which robots can be programmed.
   A.
   B.
   C.

Support Materials

- Groover, Mikell P. *Automation, Production Systems, and Computer Aided Manufacturing*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1980.

SPACE PRODUCTION SYSTEMS

Essential Elements: Common: 1A, D; 2C-F, H, I; 3B; 4C; 5B; 6A-C; 7A-D; 8D-F; 9A-D; 10A, C
Specific: 3

TAAS Objectives: Math: C 3; O 1, 2; PS 3
Reading: 1-6
Writing: 6, 7

Activity Summary

This activity will provide background information about the National Aeronautics and Space Administration (NASA) programs and space exploration. Ideas will be generated for production experiments in outer space and space simulations will occur.

Teaching Tips

1. Write to NASA for an educational packet. The address is:
   NASA Lyndon B. Johnson Space Center
   Houston, Texas 77058
   They will mail you information. They also have demonstration/lecture assembly programs that you could organize for the whole school. NASA has special classroom and seminar programs for smaller groups. If your school is near the Houston Space Center, you should try to organize a tour for your students. There are also workshops, seminars, conferences, curriculum planning activities, and instructional materials development programs for teachers.
2. Have models of a space shuttle or other space vehicles or satellites around the classroom.
3. Organize a visit from the NASA Space Center to your school. Or try to have some people who work in related areas come in and talk about careers.
4. Depending upon the maturity level of the class, you may want to discuss the issues related to the crash of the Challenger space shuttle. There are pros and cons to the social issue of spending government money to pursue a space program. Each person should make his or her own decision. The issue is complex, as there is also the cultural issue of being 'first' in space, the 'first' country to land on the moon, the 'first' country to send a probe (Voyager) past the boundaries of this galaxy, etc. Americans like to be first, to be seen by other countries as 'great,' to be considered a powerful nation, and one area where the United States has been able to provide leadership since the 1960s is in space programs. An additional activity that you could incorporate into this unit is a debate on the pros and cons of the space program. The students could be split into teams to research the issue. You, as the teacher, could act as moderator, or you could appoint a student to serve as moderator. The event could also be videotaped for critique at a later time.

Instructional Strategy

- Use the material in the Student Activity as reading material or as a lecture outline.
- If possible, relate the information on gravity to the information students may be studying in science.
- NASA will send a great deal of material, including pictures and diagrams. Use these around the classroom or in your lecture when you begin discussing the shuttle program.
- Have the students brainstorm for ideas about careers and flight components.

- Before providing answers to the questions on careers, let the students identify other components and careers. You can assign students to research the careers and report to the class what they found.
- Discuss college: bachelor's, master's, and doctorate degrees, military options, etc. Although you may not be able to provide all the requirements for each degree, you can inform the students about college in general. You could have students write to colleges in Texas for information about the specific requirements of their programs.
- Have a fish tank set up. It should be almost full of water. You will need to supervise this closely to keep problems from developing (students splashing water, etc.). If possible, have plastic nuts and bolts (maybe a child's toy set) as they will float and can create an added dimension to the simulation of weightlessness. You might also consider having a few students come up to the front of the classroom and conduct a demonstration instead of having all students participate.
- Split the class into three groups. Each group will build a model. One group will build a shuttle, another will build a space station, another will build a planet settlement. Provide the students with a scale to operate from (e.g., 10 feet to the half inch; you decide what will work best for your laboratory in terms of storage space). Use scrap materials: straws, PVC pipe, wood, metal, wire, string, etc. Encourage students to bring things in: egg cartons, etc. Have students design their component before building it. When they are finished, have them write a two-page report on their component and present it and the component to the class.

Equipment/Supplies

1. Fish tank, water
2. Nuts, bolts, screwdrivers, pliers
3. Scrap building material

Evaluation Key

1. Define the acronym NASA.
   National Aeronautics and Space Administration

2. Define *gravity*.
   the force of attraction of objects to the earth

3. List two differences in production activities on Earth and in outer space.
   Tools need to be secured.
   Combining materials might produce different results.
   Cleanups of spills will be handled differently.
   Products need to be secured.

4. List five careers related to space exploration and the education required for each position.
   Astronaut—Ph.D. in physics or related area
   Computer programmer—bachelor's or master's in programming
   Ship captain (to retrieve fuel tanks)—military ranking
   Control tower flight engineer (to direct the landing)—FAA certification
   Military jet pilot (to escort the shuttle as it lands)—college degree, military flight instruction

SPACE PRODUCTION SYSTEMS

Learn about the National Aeronautics and Space Administration (NASA) programs and space exploration and generate ideas for production experiments in outer space and space simulations.

Objectives

- To define the acronym NASA
- To define *gravity*
- To identify differences in production activities on Earth and in outer space
- To learn about careers related to space exploration

Vocabulary/Concepts Reinforced

- NASA
- Outer space
- Gravity
- Propulsion
- Crystals
- Galaxy
- Earth, moon, Mars
- Space shuttle
- Jettison
- Mission

Equipment/Supplies

- Fish tank, water
- Nuts, bolts, screwdrivers, pliers
- Scrap building material

Introduction

Star Wars. Battle Star Gallactica. Buck Rogers. Star Trek. They all have people living, fighting, playing, and dying in outer space. Are these ways of life always going to remain fiction? Can they become realities? Will space travel be common in the 21st Century? Is this something you would like to do? Being an astronaut would be a real exciting challenge and adventure for some people, but if you don't like to fly, it might not be the right career for you!

In outer space, away from the Earth's gravitational pull, things operate differently: people float, propulsion is necessary to move from place to place, food is prepared differently, and the processes used to create products change. Gravity is the force of attraction that keeps objects on the Earth, your dinner on its plate, and water in lakes and oceans where it belongs. Gravity provides a certain amount of order to life.

In space, production processes are different. Crystals grown in laboratories to study pharmaceutical drugs or proteins are flawed due to the pull of gravity. The December 1989 issue of *Science* reported that a 1988 space shuttle flight by NASA (National Aeronautics and Space Administration) had the astronauts growing crystals in space that were nearly perfect. Away from gravitational forces, crystals tend to drift apart rather than gather in the bottom of a test tube. On Earth gravity causes heat to travel up and down the crystals as they form, disrupting their development. Once crystals are grown they are studied in a process call x-ray crystallography to determine the atomic architecture of the proteins or drugs being studied. These crystals can be used to develop new drugs which could be used to treat infections or cancer. There is a lot of exciting research connected with the space shuttle program.

The space shuttle program run by NASA has been operational since 1981. What makes the shuttle program different from previous missions is that the spacecraft itself and its two fuel tanks are reusable. The fuel tanks are jettisoned off before the shuttle leaves the Earth's atmosphere. The shuttle itself lands at Edwards Air Force Base in California just like an airplane would: retractable wheels lock into place, the plane slows down until the wheels touch, and then the brakes are applied. Each shuttle built is designed to conduct 100 flights (NASA Facts, 1983, "The Shuttle Era").

Each mission usually puts some type of satellite into orbit and conducts experiments. On Challenger's second mission in space (June 1983), several experiments were conducted. These experiments tested the "effects of space on the social behavior of an ant colony, on radish seeds, germinating snowflowers, liquid mercury, and soldering operations" (NASA Mission Report, MR-007, 1983, p. 2). Production activities in space have some differences from production activities on Earth. Most of these differences have to do with the lack of gravity. Some of these differences are the necessity of securing tools and products, different results when materials are combined, and different methods for cleaning up spills.

The space program run by NASA has many goals. They would like to develop a space station where people could live and work; put permanent stations on the moon and on Mars; explore beyond the boundaries of our galaxy; and create production facilities to make products away from the gravitational pull of Earth. What are some of the careers that would be involved in the flight of the space shuttles? What are the components of a flight?

1. the actual shuttle
2. the launching pad area
3. Mission Control
4. astronauts
5. landing crews
6. fuel tank retreival teams

Explore each of these components (and any others you thought of) further: What types of careers are involved in producing a shuttle? The actual production crew that builds the shuttle, engineers and designers to create the shuttle, researchers to determine its safety, electricians to wire its, and programmers to run its computers are just some of the many people needed to make the shuttle a reality. Identify other careers related to other aspects of the shuttle flight. Determine what qualifications would be needed for some of these jobs. Some examples would include:

1. Astronaut—Ph.D. in physics or related area
2. Computer programmer—bachelor's or master's in programming
3. Ship captain (to retrieve fuel tanks)—military ranking
4. Control tower flight engineer (to direct the landing)—FAA certification
5. Military jet pilot (to escort the shuttle as it lands)—college degree, military flight instruction

Now comes time for some experimentation. To simulate the weightlessness that would occur in outer space, fill a fish tank with water. Use some nuts, bolts, and a screwdriver to see how quickly you can bolt some pieces of metal together. Is it more difficult than doing it outside the fish tank? If you dropped one of the nuts or bolts, did it float away? Were the objects harder to manipulate?

Working in three groups, you must now design and build a shuttle, a space station, and a settlement on the moon or Mars. The components must interface, be proportional, and be of the same scale and size. Each group must then present a two-page report and their work to the rest of the class. Blast off!!

Procedure

1. Read materials provided by the teacher. Discuss the space program.
2. Identify careers at NASA and in the space shuttle program.
3. Conduct the experiment with the fish tank.
4. Divide into three groups.
5. Brainstorm for ideas for your assigned part of the mission.
6. Use scraps of materials to build your module.
7. Write a two-page report about your module and present it to the class.

Evaluation

- Define the acronym NASA.
- Define *gravity*.
- List two differences in production activities on Earth and in outer space.
- List five careers related to space exploration and the education required for each position.

Support Materials

- Materials from NASA
- Library information on outer space
- Models of any space shuttles

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 11
(4 WEEKS)

HUMAN-POWERED VEHICLE

Essential Elements: Common: 1A-D; 2C, E, H; 4C, D, F; 6A-C; 8F; 9A, D; 10A-C
Specific: 1, 2, 4, 5, 8
TAAS Objectives: Math: C 1, 4; O 1-4; PS 1-4

Activity Summary

Using discovery and exploration, the student will design, build, and test a prototype human-powered vehicle.

Teaching Tips

1. There is a strong possibility that not all students will have the skills that are necessary for the actual building of this vehicle. This being the case, you may have to teach specific skills on a "need to know" basis. Set specific guidelines (e.g., max./min.wheelbase, number of wheels, max. of weight/height, self-recovering, etc.) so that students have a frame to guide them.
2. Stress team communication so that each team member understands the overall concept and individual responsibility.
3. Keep teams small (5 or less). This can be a *very* inexpensive project. A little resourcefulness on the part of the students can go a long way. Bicycle shops can help with used/abused parts that are worthless to them but perfectly suited for this, at little or no cost.
4. Be certain to discuss suspensions, center of gravity, wheel alignment, drive train, brakes, etc.

Instructional Strategy

- This is perfect opportunity to "give the student his head" and let her/him run with an idea. Encourage bold solutions to problems yet keep the teams within the guidelines. You may be surprised at the resourcefulness and imagination of your teams. Encourage brainstorming and remind the students that in the early stages of this project, nothing is too crazy! Have fun.

Equipment/Supplies

Any reasonably well-equipped Technology Education laboratory should be able to handle the production of a human-powered vehicle. Other supplies will be determined by the individual vehicle designs and provided largely by the student.

Evaluation Key

Test entire vehicle:

1. Do all systems operate properly?
2. How does the vehicle handle? Is it stable?
3. Is the vehicle sized for many different drivers or just one?
4. Is it easily serviced in case of breakdown?
5. How efficient is the vehicle?
6. Does the vehicle fit the criteria set at the beginning?
7. Did all team members do their fair share of the work?

HUMAN-POWERED VEHICLE

Use your imagination and skills to produce a working prototype.

Objectives

- To apply skills and knowledge of design, manufacturing, testing, evaluation, and refining to the production of a prototype human-powered vehicle, while working in a team within specific guidelines

Vocabulary/Concepts Reinforced

- Prototype
- Wheelbase
- Center of gravity
- Alignment
- Drive train
- Brakes

Equipment/Supplies

- Determined by individual vehicle plans

Introduction

With the diminishing reserves of fossil fuels, and the increased cost of personal transportation, mankind will need to explore and develop alternate means of powered transportation vehicles. These can and will include human power. What we will do here is develop an HPV (human-powered vehicle).

Procedure

1. With your team establish some overall goals and concepts for your vehicle. Remember, there are no wrong solutions, as long as your solution falls within the guidelines set by your instructor.
2. Be creative. Make as detailed a set of plans as possible. It is much easier, and quicker, to erase a line than take apart and redo an actual object.
3. Make certain your design can start, stop, operate (run), and steer!
4. Always make safety your first priority.
5. Construct your prototype.
6. Check subsystems as you go.
7. Evaluate and revise as necessary.
8. Exercise caution when testing.
9. Wear and use appropriate safety items (helmet, goggles, gloves, etc.).

Evaluation

Test entire vehicle:

1. Do all systems operate properly?
2. How does the vehicle handle? Is it stable?
3. Is the vehicle sized for many different drivers or just one?
4. Is it easily serviced in case of breakdown?
5. How efficient is the vehicle?
6. Does the vehicle fit the criteria set at the beginning?
7. Did all team members do their fair share of the work?

Suggestions for Improvement

Fill this section out after you have completed the project.

If this project was repeated in the future, and if you were put in charge, what would you do differently to improve the project?

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 12
(1 WEEK)

THE TOWER OF PASTA

Essential Elements: Common: 6A, B; 8F; 9A; 10A, B
Specific: 3, 6, 10, 11
TAAS Objectives: Math: C 1-4; O 1-4; PS 1-4

Activity Summary

A demonstration, exploration, discussion, and application of the fundamental principles of structure in building. The students will examine the effect of load from different directions on different shapes. They will apply this knowledge and the conclusions reached in the design and construction of a tower. This tower will be made of spaghetti and white glue (Elmer's type), on a 6" square base. The goal is to build the tallest tower possible.

Teaching Tips

1. As the activity progresses, the amount of student participation increases from next to nothing to 100 percent in a very short time. The actual construction should be entirely undertaken by the student.
2. As the geometric shapes are constructed, the straws may be attached by flexible tubing, straight pins, one side of a staple, etc. The idea is to make a joint that will pivot so as to illustrate that it is the shape of the structure, not the joint, that provides the strength and rigidity.
3. Guide the student discussion of observations and comparisons, but let the students reach their own conclusions! The validity of these conclusions will be apparent with time and the construction of the tower.
4. When discussing compression and tension, point out that these are two of the main forces to contend with, and illustrate and/or demonstrate them. Be certain to point out that other forces exist and may need to be contended with (e.g., torque, inertia, etc.).
5. It is very important that the students build on a solid, level base at all times.
6. If available, hot glue guns can be used in lieu of white glue. This will decrease the construction time by virtually eliminating the curing time of the glue. If these are used, be certain to include appropriate safety instruction.
7. Do not allow students to coat or cover the entire structure with glue. We wish to demonstrate structural strength, nothing else!

Instructional Strategy

- Once instruction on the basic geometric shapes is given, check for comprehension, then do not volunteer any information. Let the students do the design and construction work so they may acquire as much experience as possible.
- It may be useful for later evaluation to take a series of still photographs or videotape the various stages of construction. Video would be more convenient, but photography would allow for side-by-side comparisons.

Equipment/Supplies

1. Chalkboard or overhead
2. Casein glue (Elmer's type)
3. Spaghetti
4. 6"x 6" cardboard or similar material
5. Empty can (with ends cut out)

6. Small empty cardboard box
7. Drinking straws

Note: Hot glue guns may be used instead of white glue to expedite construction.

Variations

- Have students work in teams. Build for maximum height, but make the tower support a given or standard load. Have it built for maximum height and maximum load. Figure efficiency of tower.

Evaluation Key

Compare each structure according to the criteria established in the challenge. If it met the criteria, have the student provide a written and/or oral explanation of why and how he/she settled on that particular design. Is the student satisfied with the results? If it had to be done over again, what would he/she change and why?

THE TOWER OF PASTA

"Reach for the sky" as you attempt to apply the information acquired in this module to a practicable structure.

Objective

- To demonstrate a working knowledge of the principles of structure and geometric support

Vocabulary/Concepts Reinforced

- Structure
- Load
- Rack
- Perpendicular
- Compression
- Tension

Equipment/Supplies

- Casein glue (Elmer's type)
- Spaghetti
- 6" x 6" piece of cardboard or similar material
- Empty can (with ends cut out)
- Small empty cardboard box
- Drinking straws
- *Note:* A hot glue gun may be used instead of white glue to expedite construction.

Introduction

The adage "the whole is greater than the sum of its parts" is true in the application of the principles of structure. The object is to take as light and delicate a structure as possible and make it hold the most weight and endure the most abuse. Simple in concept, difficult in application.

Procedure

1. Let us take the basic geometric shapes and examine each with regard to strength and rigidity.
2. **Circle.** As a load is applied to the edge of a circular object, the shape deforms and begins to take on the shape of an oval. As long as the circumference can maintain a smooth shape, its structural integrity is maintained. Try to prove this with an empty soda pop can, making observations for later comparisons.
3. **Square/rectangle.** If a load is applied to the side of a square, the load will be transmitted from the side of the load to the adjoining sides through the connecting corners. As long as the load is perpendicular to the side, structural integrity is maintained; however, if the load is at any other angle than 90 degrees, the structure will begin to "rack" and its integrity will be determined only by the strength of the corners. Take a cardboard box, take out the ends making, in effect, a tube, and apply loads to demonstrate this. Make observations for later comparisons.
4. **Triangle.** As a load is applied to a triangle, the load is distributed from the load side to the adjoining sides through the corners. (Now, where have we

seen that before?) Take 3 drinking straws and form a triangle. Place loads on it from different angles. Make observations for later comparisons.

5. **Pentagon.** Take 5 drinking straws and make a pentagon. As with the triangle, apply loads on it from different angles. Make observations for later comparisons.

Evaluation

Does your structure meet the critieria established in the challenge? If so, provide a written and/or oral explanation of why you settled on that particular design. Are you satisfied with the results? If you had it to do over again, what would you change and why?

- What comparisons can be made between the application of load and the reaction of the shape?
- Which shape is the most rigid?
- Which has a better overall structure?
- Do all structural members need to be rigid in nature? Why?
- What two forces are we dealing with most often when we are talking about structure, and how do these forces determine the materials used in the construction of structures?

Challenge

On a 6" x 6" base provided by your instructor, construct a freestanding tower, using your knowledge of structure. The maximum height of the tower will be determined only by the imagination, skill, and resourcefulness of the student/builder. Reach for the sky!

MATERIALS ASSEMBLY

Essential Elements: Common: 2D, H; 7A; 8A; 9A, B; 10B
Specific: 1, 2, 3, 5
TAAS Objectives: Math: C 1, 2, 4; O 1-4; PS 1
Reading: 1, 3, 5, 6
Writing: 1, 2, 4

Activity Summary

Students will gain a working knowledge of the options available to them in materials assembly and an understanding of some of the industrial processes.

Teaching Tips

1. Be prepared to demonstrate as many types of fasteners and procedures as possible on as many types of materials as possible (e.g., epoxy on wood, metal, glass, plastic, etc.; hide glue on wood, metal, glass, plastic, etc.).
   Time frame:
   1st day—overall discussion
   2nd day—demonstration/application
   3rd day—testing/evaluation
2. Prepare mechanical joints ahead of time as they are time-consuming and individual need can be met at a later date.
3. When discussing fasteners, be sure to include threads (both internal and external), clearance holes, pilot holes, etc. When talking about welding, include in the discussion oxyacetylene, arc, MIG, plastic, and any other form available to you. Point out that this is an overview of welding processes, not a welding lesson, and that actual instruction on welding will be given separately.
4. When discussing the use and application of chemical fasteners, cite the increased use of chemical bonding in the aircraft, automobile, and shipbuilding industries.
5. As always, *stress safety*. We have here the opportunity for cuts, pinches, shock, burns, fire, etc. Most of the chemicals are carcinogenic. Teach proper preparation. Read the labels. Have sufficient ventilation. Use appropriate safety equipment. Check for comprehension and retention of *all* safety rules and activities.

Instructional Strategy

- It should be noted that the purpose of this lesson is to provide the student with a resource, not to make the student an expert on attaching one surface to another.
- Test assembled pieces by pushing, pulling, hitting, submerging, and any other means at your disposal.
- Be creative.
- Be certain to label each material, fastener, and adhesive being used *as you go* so as to not trust to memory and be able to make accurate evaluations later.

Equipment/Supplies

Several pieces each of as many different types of materials as possible:

1. Glues (hide, casein)
2. Epoxy

3. Contact cement
4. Hot glue gun/glue sticks
5. Nails
6. Screws
7. Nuts and bolts
8. Rivets (pop and cold)
9. Drill and bits
10. Corrugated fasteners
11. Hammer

Evaluation Key

Since this lesson is a resource, evaluation can range anywhere from simple, but accurate, visual observations to full-blown compression/tension/sheer testing with hydraulic force generators and dial indicators. The latter may be overkill. It could be very useful to have the students chart the results so as to have an instant reference available to them for future comparison.

MATERIALS ASSEMBLY

Acquire a firm basis from which to make design assembly decisions.

Objectives

- To gain a working knowledge of materials assembly procedures

Vocabulary/Concepts Reinforced

- Bolt
- Nut
- Tap
- Die
- Pilot hole
- Clearance hole
- Rivet
- Nails
- Casein
- Epoxy
- Hot glue guns

Equipment/Supplies

Several pieces each of as many different types of materials as possible:

- Glues (hide, casein)
- Epoxy
- Contact cement
- Hot glue gun/glue sticks
- Nails
- Screws
- Nuts and bolts
- Rivets (pop and cold)
- Drill and bits
- Corrugated fasteners
- Hammer

Introduction

By this time we have learned something of design, layout, cutting out, and fabricating individual pieces of material. What we will do here is discuss and demonstrate how to assemble the pieces into a whole.

Procedure

Let's separate the tools of assembly into groups for ease of study.

1. Mechanical
    - A. Joints can be used in almost any material, however the ease or difficulty of producing these joints will determine their practicable application. These joints include; dovetail, dowel, mortise and tenon, etc.
    - B. Fasteners include, but are not limited to, nuts and bolts, nails, screws, rivets, welded connections, snap rings, corrugated fasteners, and external types.

2. Chemical
   A. Traditional—These are the basic type, such as hide glues and casein.
   B. Modern—The use of chemical fasteners is rapidly growing. These include contact cements (both solvent and water-based), epoxies, hot glues, and caulking.

After the class discussion on these materials or tools of assembly, we will take the material samples and begin assembling them using as many different types of fasteners and/or adhesives as possible. Be certain to label each as you go for later identification and evaluation. *Observe all safety rules/and procedures.*

Evaluation

- How did the mechanical joints and fasteners compare with one another? List strengths and weaknesses.
- How do traditional and modern chemical adhesives compare? List strengths and weaknesses.
- On what basis would you make a decision as to which type(s) of assembly procedure(s) to use?

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 14
(3 DAYS)

USING ROBOTS IN INDUSTRY

Essential Elements: Common: 4B; 8E; 9A; 10B
Specific: 9
TAAS Objectives: Math: C 1, 4; O 1; PS 1, 2, 4
Reading: 1-3, 5

Activity Summary

This activity is designed to give students an idea of how robots could be used in industry. Students will be given an industrial plant layout and will program a robotics vehicle to maneuver through it. Besides guiding the vehicle through the plant, the program will have to take into consideration the safety of the people who are working there.

Teaching Tips

1. Make a large plant layout on poster board and laminate it, or mount it on a table and cover it with a plastic film.
2. Set up your plant layout so WAO cannot fall.
3. The pins that connect WAO to the computer are very delicate, so you may want to show the students how to carefully connect them.
4. If a student types in a number smaller than 1000 by mistake, she/he will be changing the program that runs WAO.
5. If you use this activity very much, rechargeable batteries would save a lot of money.

Instructional Strategy

- Make this a small group activity (2 people).
- Have students program WAO directly, before programming it with a computer, in order to determine the lengths of each value 1-6.
- Have students write out the program before they start entering the program on the computer.

Equipment/Supplies

1. Poster board for plant layout
2. WAO Robot (You can get them already assembled or in a kit.)
3. WAO interface for the type of computer you have in your lab
4. 3 AA batteries
5. 9-volt battery
6. Computer system compatible with the WAO interface
7. Data disks

Evaluation Key

1. Group participation
2. Written program
3. Final program saved to a data disk
4. How the WAO runs from the computer program

Support Materials

- *The Robotics Revolution*. Washington, D.C.: National Geographic Society, 1986. Video.
- *WAO Instruction Book*. Elehobby.

USING ROBOTS IN INDUSTRY

Study how robots could be used in industry.

Objectives

- To understand how robots can be used in a production system
- To use computer-controlled systems in production
- To gain a better understanding of arbitrary units of measure
- To successfully participate in group activities

Vocabulary/Concepts Reinforced

- Robot
- Plant layout
- Units
- Programs
- Computer
- Data
- Automation

Equipment/Supplies

- Poster board for plant layout
- WAO Robot
- Computer with WAO interface
- Data disks
- 3 AA batteries
- 9-volt battery

Introduction

Imagine yourself working for a computer firm that deals strictly in programming. You have just received the memo below, a model of the WAO robot, and a plant layout of the new General Dynamics plant. You have some information about how WAO operates and you have to program WAO to move about safely in that plant. Please read the following memo and proceed with the instructions that follow. See if you can program WAO to go from *start* to *finish* by going by three stations at three different tables.

MEMO

> We have recently been sent some information about a new transportation robot that will be used in the new General Dynamics plant. This company is building the new **Stealth Bomber**.
>
> Because of the secrecy involved in the production of this bomber, most of the work will be computerized. The company has sent us a floor plan of their plant and some information about the programming of their new robot, called WAO. Please use this information to write a program that will take the WAO through the stations as numbered. It is very important that some kind of warning be given at intersections because there will be a few people working at the plant. It would cause bad publicity if an employee was run over by a robot from our plant.

Procedure

1. First you will need to determine just what WAO will do. To do this, you will need to begin programming WAO directly, using the buttons on the back. Make sure that the two WAO switches are turned to **program** and **on**. After checking the switches, push the button that is marked with the orange word **direct.** (NOTE: During this stage the **orange** labels are the ones we will be using). The light should come on when the button is pushed.
2. Next, you will need to clear all information from WAO. This is done by pushing the black button on the front, passenger side of WAO. (NOTE: When WAO is in **program** mode, this black button is the **clear** or **reset** button, but when WAO is in the **run** mode, this button is the **go** button.) The light should go out when you push this button.
3. You are now ready to program. When programming, you are limited to 27 commands. Whenever you give the robot a command, the light should light up. After the light comes on, you need to give it a value of 1-6. The commands are found in orange on the top and second rows of buttons. The units 1-6 are found on the bottom row, also in orange. You must always enter a command first and then a value or unit. Be very careful that you do not hit a command or a unit button twice or you will get an error light and have to start over. If you need to start over, you push the **reset** button and then WAO is ready for another command.
4. After you have finished, turn the program switch to **run**, set WAO on the table or floor, and push the **go** button (the same button as **reset** when in the **program** mode). After completing the run, if you would like to see WAO run again, just push the **go** button. WAO will keep that program in its computer until you turn it off or start another program.
5. When you have experimented with WAO and know what measurements go with the units 1-6, you are ready to get your program sheet and begin writing a program for the computer.

Programming Instructions

1. Each movement of WAO is programmed by writing one line of a 26-line program. Each line will start with a number. Begin with **1000** and increase each line by 10:
   1000
   1010
   1020
2. After the number on each line, skip one space and then type in the word **Data**. Each line must have a number followed by the word **Data**.
3. Skip a space after **Data** and type in the command for WAO. The command will be in two parts. First, you will tell the robot what you want it to do. Second, you will tell it how long to continue or how far to go with that command. Below is a list of commands and what they stand for. Any mistake in typing will automatically freeze up WAO and he will not do anything. After each line is complete, hit **return** to start the next line.

FD	Forward	LEFT	Left
LT	Left Turn	RIGHT	Right
RT	Right Turn	LIGHT	Light
BK	Backward	BUZZ	Buzzer

For length, you will use numbers 1, 2, 3, 4, 5, or 6.

Example:

```
1000 DATA FD 3
1010 DATA RT 4
1020 DATA FD 3
1030 DATA BUZZ 6
```

This program will tell the robot to go forward 3 units, turn right 4 units, go forward 3 units, and then beep or buzz for 6 units.

4. When you are through programming, type in the last two lines. They are as follows:

```
1250 DATA END
1260 DATA COMPLETE
```

5. After completing two lines, type in **Run** and then hit return. If your program has been typed correctly, you will see the message SEND DATA TO WAO, OK? (Y OR N). If this message does not appear, you need to go back and correct any mistakes. You can go back and see your program by typing in LIST 1000- and hitting **return**.

   If the following message appears: 3 RIGHT 3 THE FIRST, "the first" means that your mistake is on the 3rd line. The other information will be the information you typed on line 3. As you can see, "right" is misspelled, as it should read RT. If a number does not appear after RIGHT, then you forgot to tell the computer how many units you wanted the robot to move. Retype only the line that needs correcting. Be sure that you do not leave any blank spaces after any line.

   ```
   1020 DATA RT 3
   ```

   Then hit **return** and type in **run**. Hit **return** again and you will see either the message mentioned above or another mistake. Continue corrections until all mistakes have been corrected.
6. When this is complete, you are ready for WAO. Make sure that the WAO switches are placed on PROGRAM and ON. There should be a cable coming out of the computer with a brown wire on one end and a black wire on the other end. The brown should be on the left when connecting it to the pins on WAO. Be extremely careful, because the pins can be bent very easily. When the connection is made, the light on the left should come on. Press the reset button on the front of WAO once, and the light should go off. You are now ready to SEND DATA TO WAO, OK? Type a Y and then hit **return**. You should see the light go on and off very quickly as the computer is sending the program to WAO. Turn the switch to RUN, unplug the connector, set WAO down at the START mark, and press the GO button.

Evaluation

- Group participation
- Written program
- Final program saved to a data disk
- How the WAO runs from the computer program

Support Materials

- *The Robotics Revolution*. Washington, D.C.: National Geographic Society, 1986. Video.
- *WAO Instruction Book*. Elehobby.

Program Worksheet

1000 ______________________________

1010 ______________________________

1020 ______________________________

1030 ______________________________

1040 ______________________________

1050 ______________________________

1060 ______________________________

1070 ______________________________

1080 ______________________________

1090 ______________________________

1100 ______________________________

1110 ______________________________

1120 ______________________________

1130 ______________________________

1140 ______________________________

1150 ______________________________

1160 ______________________________

1170 ______________________________

1180 ______________________________

1190 ______________________________

1200 ______________________________

1210 ______________________________

1220 ______________________________

1230 ______________________________

1240 ______________________________

1250 ______________________________

1260 ______________________________

(1 WEEK)

CONSUMER GOODS: WHERE DO THEY COME FROM?

Essential Elements: Common: 4F; 9C; 10C
Specific: 3, 8
TAAS Objectives: Reading: 1, 3, 5
Writing: 1-4

Activity Summary

This activity is designed to encourage students to think about the total process used in producing consumer goods. Students will work in groups to trace a product that is frequently used in their homes from the raw materials used in the production of that item. Each group will be responsible for developing a flowchart with illustrations, as well as making a presentation to the class.

Teaching Tips

1. Work through one flowchart as a class.
2. Possibly have a completed chart to display in your classroom.
3. Students should make a brief presentation to the class of their chart.
4. Different products could be assigned to different students.

Instructional Strategy

- Make this a group activity.
- Have students document the progress of their charts.
- Have some resource materials available.

Equipment/Supplies

1. Poster board
2. Marker, map colors, or other coloring tools
3. Magazines that can be cut
4. Scissors
5. Glue or paste
6. Construction paper
7. Computer (optional)

Evaluation Key

1. Final flowchart
2. Presentation
3. Participation of each member of the group
4. Written report

Support Materials

- Hacker, Michael. *Living with Technology.* Albany: Delmar Publishers, 1987.
- Hacker, Michael. *Technology in Your World.* Albany: Delmar Publishers, 1987.
- Wright, R. Thomas. *Understanding Technology.* South Holland, Ill.: Goodheart-Willcox Co., Inc., 1989.

CONSUMER GOODS: WHERE DO THEY COME FROM?

Study how consumer goods are produced.

Objectives

- To gain a better understanding of consumer goods
- To be able to form a logical sequences of events
- To trace materials from the raw state to the finished product
- To be able to use different resources to gather information

Vocabulary/Concepts Reinforced

- Resources
- Sequence
- Raw materials
- Finished product
- Consumer
- Flowchart
- Parts list

Equipment/Supplies

- Poster board
- Marker, map colors, or other coloring tools
- Magazines that can be cut
- Scissors
- Glue or paste
- Construction paper
- Computer (optional)

Introduction

We use different machines, tools, and products every day. Some of these are very complex and some are very simple. Some will last a lifetime, and some will be discarded shortly after they are used. As consumers we use these products, but very few of us are familiar with their origins.

As we study production, we need to take a close look at the things we use every day and develop a better understanding of the process involved in getting these products into our homes. Many products that we use today have many parts. Some of these parts have had to go through a number of processes before becoming a part of the product. How many parts, and how many processes, were used to get your television into your living room or bedroom? Where did this all begin? These questions all have answers, and it is your job to find out what those answers are.

Procedure

1. The first step in this activity is to choose an item in your house that you use frequently. After choosing this item you will need to make a list of all the parts that make up the item you picked. You will then try to trace those parts through the processes that formed and shaped them into their final state, and to determine the raw materials that were used in making them. The next question you will need to answer is where the raw material came from.

2. After completing your lists you will need to make a flowchart to show the exact sequence of events that took place to get your item to the place where you use it today. This chart should be done in such a way that it can be presented to the class, or put on display and be self-explanatory. Please include pictures, graphics, or illustrations with your flowchart. These will help other students understand the processes used to finish your item. After completing your flowchart, you will need to write a short report explaining the outcome of your research, and present your report and flowchart to the class in a short oral presentation.

Pencil—
- —Eraser—(shaping processes)—(milling processes)—(origin)—(etc.)
- —Wood—(shaping processes)—(milling processes)—(origin)—(etc.)
- —Metal—(shaping processes)—(milling processes)—(origin)—(etc.)
- —Graphite—(shaping processes)—(milling processes)—(origin)—(etc.)
- —Paint—(shaping processes)—(milling processes)—(origin)—(etc.)

Partial flowchart without illustrations. Include drawings, pictures, or graphic representations along with the processes.

Evaluation
- Final flowchart
- Presentation
- Participation of each member of the group
- Written report

Support Materials
- Hacker, Michael. *Living with Technology*. Albany: Delmar Publishers, 1987.
- Hacker, Michael. *Technology in Your World*. Albany: Delmar Publishers, 1987.
- Wright, R. Thomas. *Understanding Technology*. South Holland, Ill.: Goodheart-Willcox Co., Inc., 1989.

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 16
(2 DAYS)

NAME THAT MATERIAL

Essential Elements: Common: 9B; 10C
Specific: 1, 2
TAAS Objectives: Math: PS 2
Reading: 4, 5
Writing: 2

Activity Summary

In this activity students take a variety of materials and try to describe them. A student will be allowed to feel a type of material, such as a polymer, a metal, wood, etc., and then he/she will describe as many properties of that material as possible without seeing it. The other students should be arranged so they cannot see the object being described. Students will try to guess the type of material from the description given by the student.

Teaching Tips

1. You will need a wide variety of materials, preferably one sample for each member of the class.
2. You will need something like a box that students can reach into without seeing what is inside.
3. The classroom should be arranged so that the students cannot see the objects that are being described.
4. Assign each sample a number.

Instructional Strategy

- Have students gather as much information as possible about the properties and characteristics of different types of materials before the second class period.
- Have each student keep records of words used to describe each material.
- Have each student write a summary of the class findings to determine similar characteristics among similar materials.

Equipment/Supplies

1. Boxes to hide the materials in
2. Different types of metals, polymers, woods, organic materials, and composite materials

Evaluation Key

1. Vocabulary quiz
2. Participation in materials description activity
3. Written conclusion to the description activity concerning properties and characteristics of materials

Support Materials

- Johnson, Harold V. *Manufacturing Processes.* 2d ed. Peoria, Ill.: Bennett Publishing Co., 1984.
- Lindbeck, John R. *General Industry & Technology.* Peoria, Ill.: Bennett McKnight Publishing Co., 1986.
- Watson, Don A. *Construction Materials and Processes.* 3d ed. New York: McGraw-Hill Book Co., 1986.

NAME THAT MATERIAL

Learn how to identify various types of materials.

Objectives

- To be able to determine a type of material from verbal descriptions
- To formulate conclusions based on the information given
- To use resource materials to gather information

Vocabulary/Concepts Reinforced

- Properties
- Characteristics
- Polymers
- Metals
- Woods
- Composites
- Organic

Equipment/Supplies

- Boxes to hide the materials in
- Different types of metals, polymers, woods, organic materials, and composite materials

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Introduction

During this activity you will be learning about a variety of materials. It is important to know some of the characteristics and properties of different materials. By the end of this activity you will have been exposed to several types of materials and will have discovered how they should be classified.

Procedure

1. On the first day, you will need to find as much information about the different types of materials as you can. Pay close attention to their properties and characteristics.
2. On the second day, you will need to have all the information with you for the exercise. One student at a time will need to reach inside one of the boxes and examine the material that is inside. That student will begin describing that material. You will need to write down the number on the box that has the material being described.
3. Each student will write down the number of the sample being described and what type of material she/he thinks it is, along with the reason for the answer. Continue this same process until all the materials have been described.
4. Check the answers to see how many you got right. Discuss the answers that were incorrect to see why you made a mistake. At the end of the activity, write some conclusions about the different types of materials and their characteristics.

Evaluation

- Vocabulary quiz
- Participation in materials description activity
- Written conclusion to the description activity concerning properties and characteristics of materials

Support Materials

- Johnson, Harold V. *Manufacturing Processes*. 2d ed. Peoria, Ill.: Bennett Publishing Co., 1984.
- Lindbeck, John R. *General Industry and Technology*. Peoria, Ill.: Bennett McKnight Publishing Co., 1986.
- Watson, Don A. *Construction Materials and Processes*. 3d ed. New York: McGraw-Hill Book Co., 1986.

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 17
(3-4 DAYS)

TYPES AND GRADES OF PRODUCTION MATERIALS

Essential Elements: Common: 7-9
Specific: 1, 2
TAAS Objectives: Reading: 1-4
Writing: 7

Activity Summary

This activity is intended to introduce students to the complex systems of material types and grades used in the production industry. Students will review several of the characteristics, properties, and functions of materials and complete a series of worksheets on the topic.

Teaching Tips

1. Read through the entire activity and become familiar with the topic before presenting it to students.
2. Create a display or bulletin board about production materials.
3. Collect and provide a variety of materials that students can observe and handle.
4. Bring an object such as a lawnmower, a bicycle, a blender, or some other complex object to class that can be semi-dismantled and the various parts analyzed according to material type and grade. Use a model building and describe the types and grades of materials used to build the real structure.

Instructional Strategies

- Lecture to present the topic to students.
- Use this activity as either a small group or individual project.
- Use the attached student worksheets.

Equipment/Supplies

1. Student worksheets
2. Miscellaneous material samples as available

Evaluation Key

Evaluation of student performance will be based on participation in the group discussion and completion of the student worksheets.

TYPES AND GRADES OF PRODUCTION MATERIALS

Review the basic types and grades of materials used in industry.

Objectives

- To describe and discuss the major types and grades of materials used in the manufacturing and construction industries
- To discuss the characteristics and functions of various materials

Vocabulary/Concepts Reinforced

- Natural materials—These are the materials used by man in their natural state. Natural materials include such things as wood, sand, coal, cotton, and animal products.
- Raw materials—These are the basic natural materials that are either combined in their natural state or processed to produce synthetic materials.
- Synthetic materials—These are materials that are manufactured from combinations of raw materials or combinations of processed raw materials.

Equipment/Supplies

- Student worksheets
- Miscellaneous material samples as available

Introduction

Mankind has developed a very complex system of production materials which he has been able to use directly as found in nature in the form of natural materials or synthesized from a combination of raw materials. Virtually thousands of production materials have been developed over the past one hundred years that have made modern technology possible. These many natural and synthetic materials are the ingredients of modern technology. Everything that man has been able to produce in both manufacturing and construction can be directly attributed to the development of modern production materials.

Production materials are classified in different ways but are generally divided into groups of similar characteristics, or families. Basically, these groups include ceramics, concretes, metals, synthetics, textiles, metals, and wood. Within each group or family is a long list of subtypes. In the metal family, for example, is a subtype called steel. Steel as a subgroup has a set of common components, such as iron, carbon, and silicone. When the proportion of any of these components is altered and when other ingredients are added to them, other levels or subgroups are obtainable.

Although some natural materials are used as they are found in nature, most are used with other materials to form mixtures or layered combinations. These combinations provide the manufacturing and construction industries with a wide variety of materials that can be used safely and efficiently to produce the products of technology.

Procedure

Complete the two student worksheets.

1. Worksheet number 1. In this worksheet students are to list several material types, their subtypes, and various products manufactured from each subtype.
2. Worksheet number 2. In this worksheet students are to review the illustrations of material combinations in which materials are either mixed together or layered. Students will then complete the worksheet by listing examples of each type.
3. In a class discussion share the ideas you have listed on the two worksheets with other members of your class.

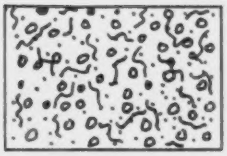
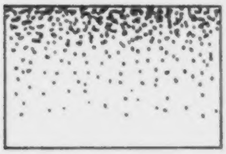
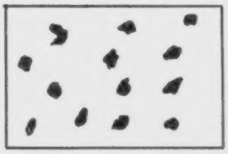
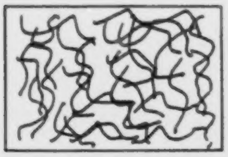
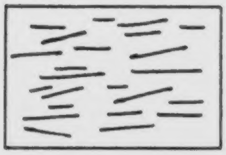
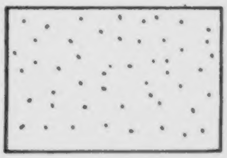
Evaluation

Teacher evaluation of student performance will be based on completion of the student worksheets and participation in the group discussion.

Student Worksheet 1—Types of Materials

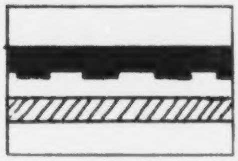
Material Type	Subtype	Product
(Example)		
Wood	Lumber	Construction Materials Furniture Telephone poles
	Cellulose	Paper Cellophane Plastics

STUDENT WORKSHEET 2
MATERIAL COMBINATIONS- MIXTURES

MATERIAL TYPE	LIST EXAMPLES
 COMPOSITES REINFORCED CONCRETE	
 DIFFUSED TINTED GLASS	
 DISPERSED PIGMENTS IN PAINTS	
 REINFORCED FIBER FIBERGLASS	
 ALLOYS STEEL	
 COMPACTED POWDER SHEETROCK	

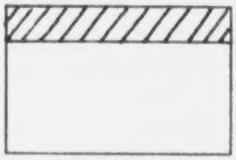
STUDENT WORKSHEET 2
MATERIAL COMBINATIONS - LAYERED

MATERIAL TYPE | LIST EXAMPLES



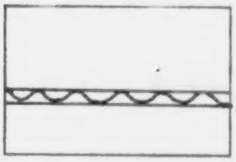
SANDWICHED

CORRUGATED CARDBOARD



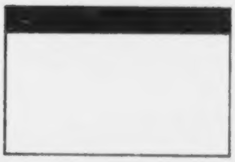
CLADDED

TEFLON FRYING PAN



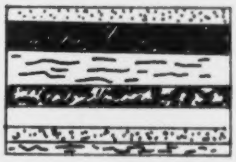
BONDED

HEAT TILES ON
SPACE SHUTTLE



COATED

HOUSE PAINT



LAMINATED

GLUE LAMINATED BEAM

CALCULATING QUANTITIES AND COSTS OF PRODUCTION MATERIALS

Essential Elements: Common: 10
Specific: 13
TAAS Objectives: Math: C 1-4; O 1-4
Reading: 1-4

Activity Summary

This activity is intended to provide instructors with a set of practical mathematical problems common to production systems. Students will work through a series of problems including volume, area, and linear measurement calculations.

Teaching Tips

1. Read through the entire activity before presenting to students.
2. Provide examples of cost estimating sheets or other pricing information which students can observe.
3. Obtain a sample of a computer material and cost estimating program for students to utilize.
4. Encourage the use mathematics by showing students its practical uses in the course work that you instruct.

Instructional Strategies

- Lecture to present the topic to students.
- Use student worksheets.
- Use the activity as an individual project.

Equipment/Supplies

1. Student worksheets
2. Computer with estimating program, if available, for demonstration purposes
3. Calculators
4. Pencils and paper
5. Samples of estimating sheets

Evaluation Key

Evaluation of student performance will be based on completion of student worksheets and participation in a class discussion of the topic.

Support Materials

- Scharff, Robert. *Workshop Math.* New York: Sterling Publishing Co., Inc., 1989.

CALCULATING THE QUANTITIES AND COSTS OF PRODUCTION MATERIALS

Review some of the basic math skills used in estimating and costing production jobs.

Objectives

- To use basic math concepts to calculate linear, area, and volume measurements
- To apply costing formulas to quantity estimates
- To apply percentage factors to estimated quantities

Vocabulary/Concepts Reinforced

- Linear measurements—Measurements of or relating to the length of a line
- Area measurements—Measurements or calculations that relate to a surface area; usually calculated in square inches, square feet, or square yards
- Cubic measurements—Measurements that have to do with the volume of a particular material; usually calculated in cubic inches, cubic feet, or cubic yards
- Percentage factors—Refers to various percentages applied to calculated quantities of materials, as in estimating waste factors

Equipment/Supplies

- Student worksheets
- Calculator
- Pencil and paper

Introduction

As students become involved in production technology course work, they will be faced with many situations in which knowledge of basic math skills is important. Students will need to calculate material quantities and cost estimates for a variety of project activities. These calculating skills are not only important to success in Industrial Technology courses but will be useful throughout life.

This activity centers on four basic calculations—linear, area, volume, and percentages. They represent most of the math functions that you will use when estimating material quantities and costs.

Procedure

Complete each worksheet contained in this activity. When you have completed each, review it with your class in a discussion of the problems.

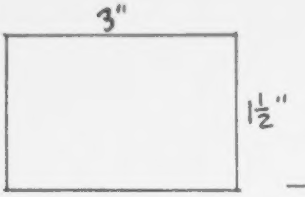
Evaluation

Evaluation of student performance will be based on completion of the worksheets and participation in class discussion of the topic.

WORKSHEET #1 BASIC MEASUREMENT

LENGTH	SCALE	DRAW LINE TO CORRECT DISTANCE
$3\frac{5}{8}$"	FULL	. .
$2\frac{3}{16}$"	FULL	. .
$1\frac{3}{4}$"	FULL	. .
$1\frac{1}{4}$"	$1\frac{1}{2}$" = 1"	. .
$2\frac{3}{4}$"	$\frac{3}{4}$" = 1"	. .
$36\frac{1}{2}$"	$\frac{1}{8}$" = 1"	. .
$52\frac{3}{4}$"	$\frac{3}{32}$" = 1"	. .
$2\frac{3}{8}$"	3" = 1"	. .
20"	$\frac{1}{4}$" = 1"	. .
$5\frac{7}{16}$"	FULL	. .
$3\frac{3}{8}$"	$\frac{1}{2}$" = 1"	. .
$16\frac{1}{2}$"	$\frac{3}{8}$" = 1"	. .

WORKSHEET #2 - LINEAR MEASUREMENT

①


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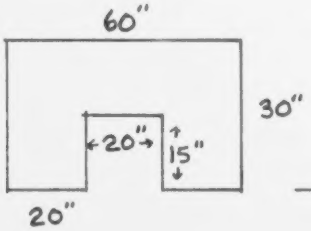
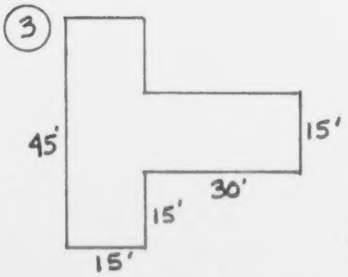

60"
30"
20"
15"
20"

____

③

45'
15'
30'
15'
15'

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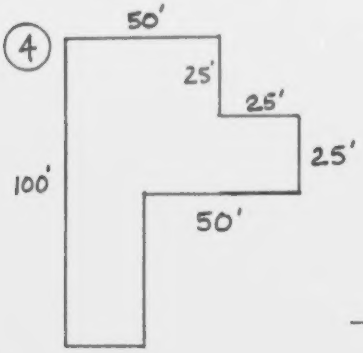
④

50'
25'
25'
25'
100'
50'

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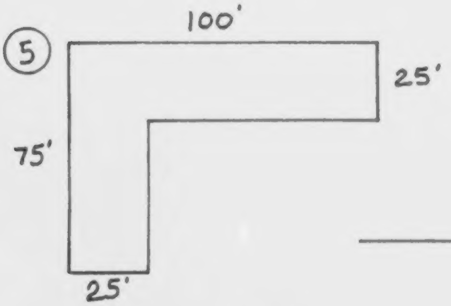
⑤


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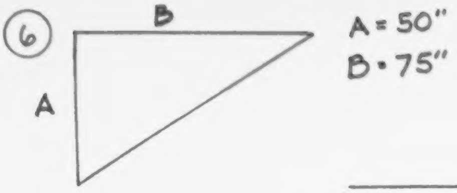

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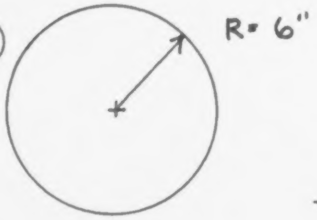

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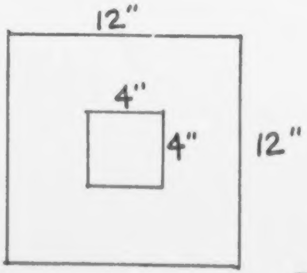

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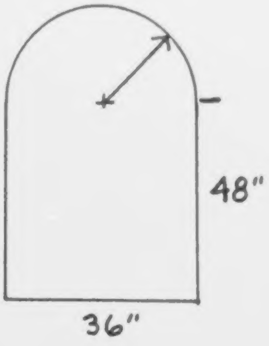

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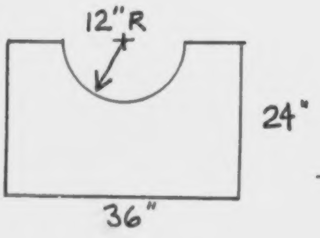

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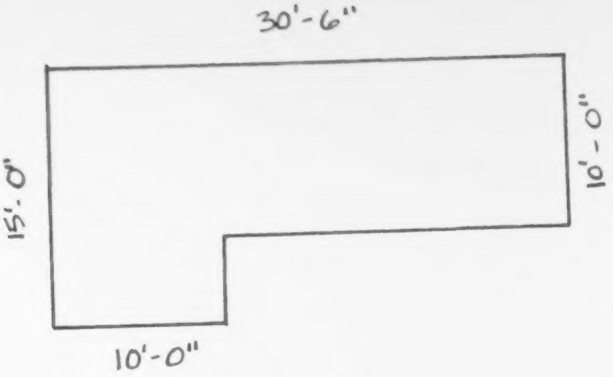
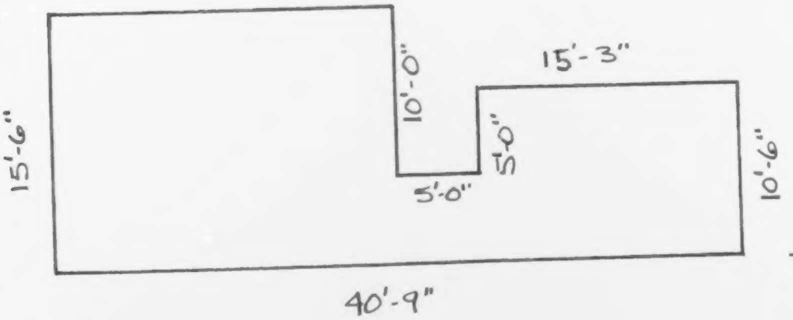

30'-6"
10'-0"
15'-0"
10'-0"

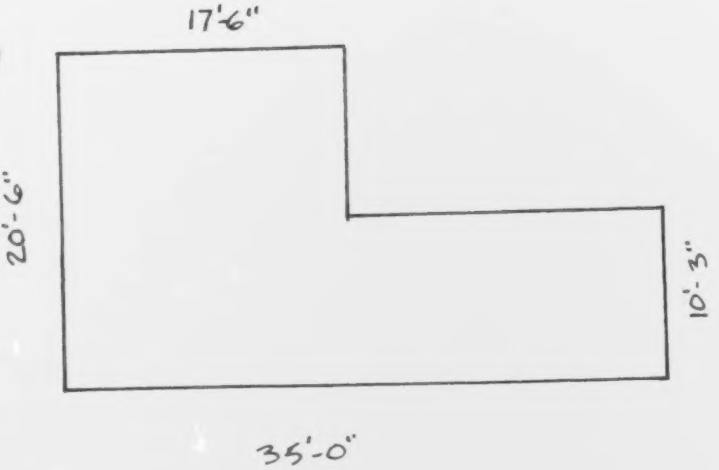
____

⑫


10'-0"
15'-3"
15'-6"
5'-0"
5'-0"
10'-6"
40'-9"

____

⑬


17'-6"
20'-6"
10'-3"
35'-0"

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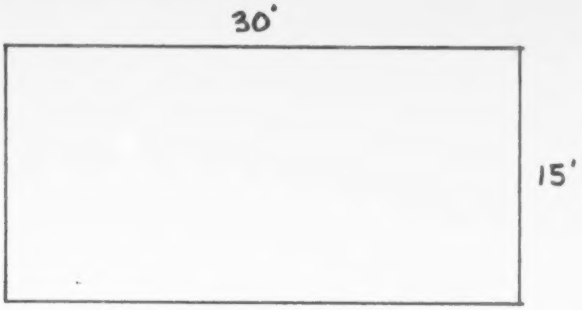
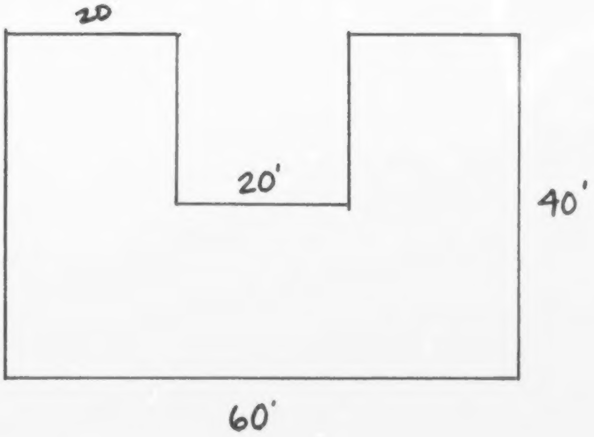
WORKSHEET #3 - AREA MEASUREMENT

①



__________ SQ.FT.

②



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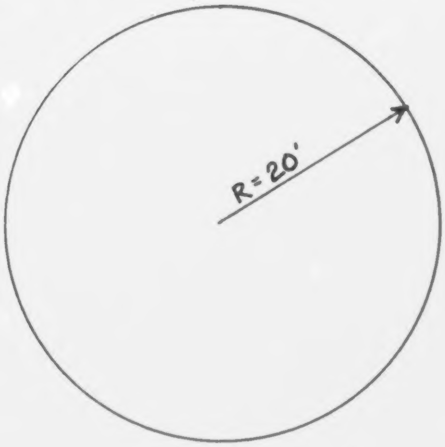
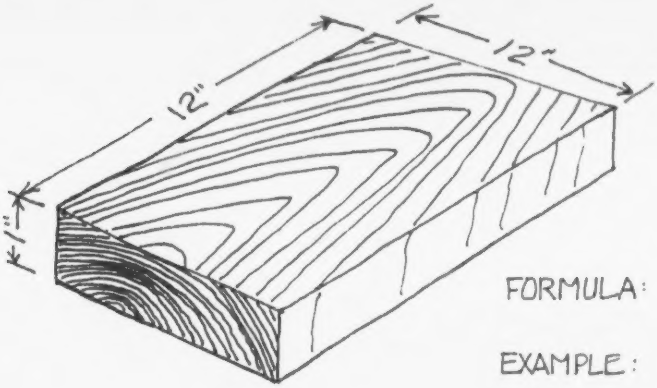


__________ SQ.FT.

WORKSHEET #4 - VOLUME



CALCULATING BOARD FEET

1 BOARD FOOT = 144 CUBIC INCES

FORMULA: $\frac{T(IN) \times L(IN) \times W(IN)}{144}$ = BOARD FEET

EXAMPLE: $\frac{1'' \times 12'' \times 12''}{144}$ = 1 BOARD FOOT

PROBLEMS:

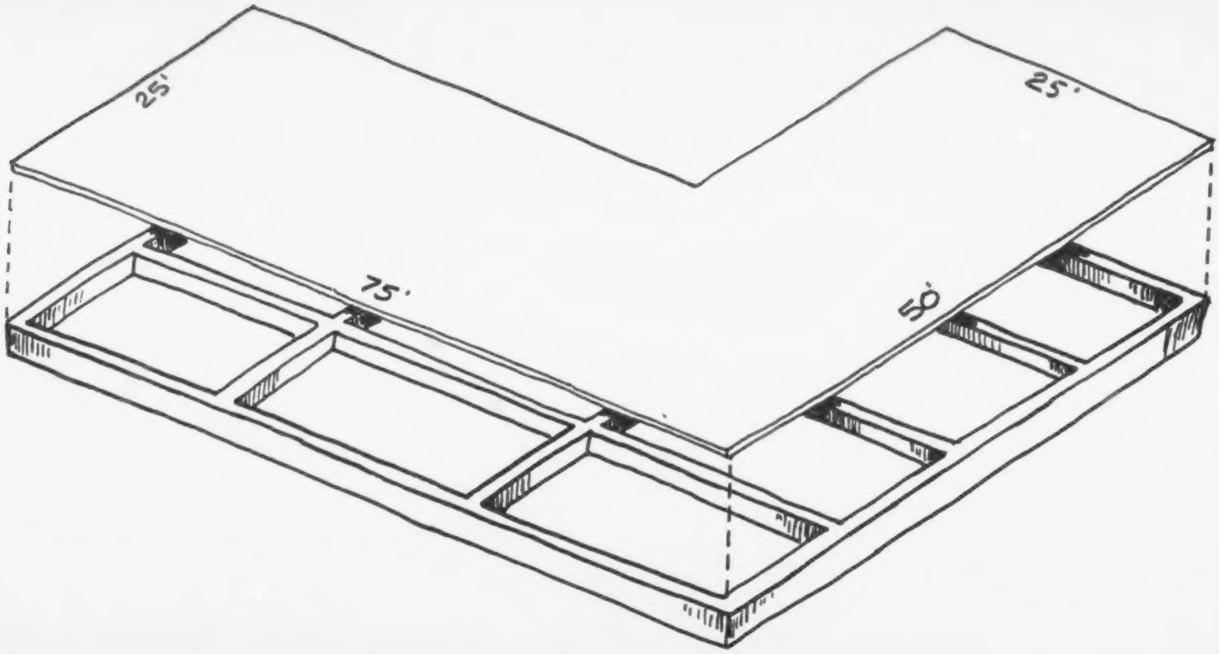
1. CALCULATE THE NUMBER OF BOARD FEET IN A PIECE OF WOOD THAT MEASURES 2" THICK x 6" WIDE x 12' LONG. ______________ Bd.Ft.
2. CALCULATE THE NUMBER OF BOARD FEET IN A PIECE OF WOOD THAT MEASURES 1" THICK x 8" WIDE x 10' LONG. ______________ Bd. Ft.
3. CALCULATE THE COST OF A PIECE OF WOOD THAT SELLS FOR $2.00 PER BOARD FOOT IF THAT BOARD MEASURES 2" THICK x 10" WIDE x 12' LONG. ADD SALES TAX OF 8%. TOTAL COST = ____________

CALCULATING CUBIC YARDS OF CONCRETE

FORMULA: $\frac{\text{THICKNESS (FT.)} \times \text{WIDTH OR HEIGHT (FT.)} \times \text{LENGTH (FT.)}}{27}$ = CUBIC YARDS

EXAMPLE: CALCULATE THE NUMBER OF CUBIC YARDS OF CONCRETE NEEDED TO BUILD A SIDEWALK 4" THICK x 4' WIDE x 20' LONG.

$$\frac{.333' \times 4' \times 20'}{27} = .9866 \sim 1 \text{ CUBIC YARD}$$



4. CALCULATE THE AMOUNT OF CONCRETE (CUBIC YARDS) NEEDED FOR THE ABOVE FOUNDATION

SLAB THICKNESS = 4"

INTERIOR AND EXTERIOR BEAMS = 12" WIDE X 24" DEEP
NOTE: CALCULATE TOTAL BEAM LENGTHS TO ACCOUNT FOR WASTE FACTOR.

__________ CUBIC YARDS

5. USING THE ABOVE INFORMATION, COMPLETE A CONTRACTOR'S PRICE ESTIMATE WHICH WOULD BE USED TO PREPARE A BID FOR THE FOUNDATION.

A. CONCRETE - $45.00 PER CU. YD.

B. MISC. MATERIALS - INCLUDES REBAR, VAPOR BARRIER, TIE WIRE, FORM MATERIAL, FILL MATERIAL, ETC. - 50¢ PER SQ. FT.

C. LABOR - 25¢ PER SQ. FT.

D. OVERHEAD AND PROFIT - 30¢ PER SQ. FT.

BID PRICE = ______________

(1 WEEK)

BASIC ROBOTICS

Essential Element: Common: 1, 8-10
Specific: 9, 14
TAAS Objectives: Reading: 1-5

Activity Summary

This activity is intended to provide instruction in basic robotics and how they can be used in various production and manufacturing applications, including space-based production. Students will learn the basic robotic types and movements, discuss various applications, and design a robotic system.

Teaching Tips

1. Read through the entire activity and become familiar with the topic before releasing to students.
2. Prepare a bulletin board display which illustrates the use of robotics in various production and manufacturing industries.
3. Show one of the many videotapes available on the subject.
4. Obtain one of the computer simulation programs which helps to simulate the operation of robotics for student use.
5. Discuss the effects of automation and robotics on future job markets.
6. Develop several robotic applications which can be assigned to students to use in designing and drawing their robotic systems.
7. Discuss the use of robotics in space-based production and construction techniques.

Instructional Strategies

- Lecture to present the topic to students.
- Use this activity as either an individual or small group project.
- Use the group discussion method in summarizing the activity.
- Use problem-solving techniques wherever appropriate.

Equipment/Supplies

1. Computer with robotic simulation program
2. Videotape which illustrates the use of robotics in industry
3. Miscellaneous materials for designing and drawing robotic systems

Evaluation Key

Evaluation of student performance will be based on participation in and completion of the project.

BASIC ROBOTICS

Explore the basic types and functions of robotic automation and design a robotic system to meet a specific application.

Objectives

- To describe and discuss the role of robotic automation in the production and manufacturing industries
- To describe the four main types of robotic coordinates
- To identify the main parts of a robotic arm
- To design and draw a basic robotic system and discuss its practical application

Vocabulary/Concepts Reinforced

- Robotics—A system of various electromechanical devices which can be programmed to perform jobs that have usually been performed by humans.
- Manipulator—The part of the robot which performs the work. This is most often a robotic arm and is made up of a base or platform and various appendages.
- Controller—The device, usually a microprocessor, which provides the operational commands to the robotic arm.
- Power sources—Robotic systems rely on a variety of power sources, including electric, pneumatic, and hydraulic.
- End effects—Special mechanical appendages used to perform difficult tasks.

Equipment/Supplies

- Computer with robotic simulation program
- Videotape illustrating industrial applications of robotics
- Miscellaneous drawing materials furnished by your instructor

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Background Information

One of the most important developments in human manufacturing and production processes in the last fifty years has been the introduction of robotic systems. Industry has realized the great potential that these mechanical devices have for improving efficiency and quality of work. They don't need a paycheck, health insurance, retirement benefits, or sick leave; they just need to be turned on and off. They can perform almost every production line function that a human being can perform, but they can do it better and more efficiently. They are also capable of doing many jobs that are hazardous or dangerous to human workers. Their application has also been of major importance to the space program and they are an integral part of the space shuttle.

In this country the main users of robotic systems have been automobile manufacturers. They use robotic systems at most stages on the production line. Robotic systems assemble body sections, weld frame members, and even apply the painted finish with great accuracy. Robotics has greatly improved production both in terms of quality of work and efficiency in manufacturing time.

In a technological sense, robotics is still very young. As technology progresses, new and more advanced robotic machines will be available to industry. Recent advances in microelectronics and computer memory have made it possible to develop very sophisticated robotic devices which are capable of performing almost any human mechanical function. The days of R2D2 and C3PO are here now. In Japan, for instance, robots are being used in some hospitals to gently lift a patient from the bed, change the bedding, and then place the patient carefully back onto the bed. In the U.S. a robotic device has been developed that will be used to clean shopping mall floors at night. It is programmed with the layout of the mall and only has to be turned on and left to perform its work. Even McDonald's is experimenting with the use of mechanical robots to run some of their restaurants. The robots will be able to take orders, prepare the food, serve customers, and, of course, take your money.

What does all this mean to the average student? What effect will these robotic machines have on your life? These are two important questions which often accompany new technology. On one hand are the positive benefits of improved quality and productivity; on the other hand are the negative aspects, such as the elimination of jobs and work.

It is important, therefore, that students understand some of the basics of robotic systems. These machines in some shape or form will be the principle means of production and manufacturing in most industries. Many employment opportunities will be tied directly to robotics. Most major universities now offer degrees in manufacturing engineering which includes robotics. Many trade and technical schools are now including training in the operation and servicing of robotic systems.

Introduction

The purpose of a robotic system is to duplicate some human mechanical function with greater accuracy and precision. These systems vary from simple to extremely complex. Their levels of complexity depend primarily on these criteria: (1) number of axes of movement, (2) load capacity, (3) cycle time, (4) accuracy, (5) power source, and (6) controller type.

However complex the robotic system, there are four primary types in use today. These are classified by the basic movement patterns which they are able to make. These movements are called axes. It is possible in some complex systems to have an operational system with as many as twenty different axes.

The first and most basic is the *rectangular coordinate system*. This system derives its name from the envelope or space within which it is able to operate. Study the diagrams which illustrate the operating axes for the various types of robots. Notice the operating envelope of the rectangular coordinate robot. It operates within this envelope by moving back and forth on the X axes, up and down on the Z axes, and in and out on the Y axes.

The second type is the *cylindrical coordinate system*. Its operating envelope is in the shape of a cylinder. It can perform its function within the operational limits of the cylinder envelope. This type of robotic arm utilizes both the Y and Z axes but also includes a rotational, or B, axis.

The third type of robot is the *spherical coordinate system*. It operates within a spherical envelope that is as large as the reach of the robotic arm. Although it is very similar to the cylindrical type, it has the added advantage of overhead reach.

The fourth type is the *revolute coordinate system*. Resolute coordinate systems are the most widely used robotics in industry. These also operate within a spherical envelope but have greater flexibility than the spherical coordinate system, which is often necessary for more complicated operations.

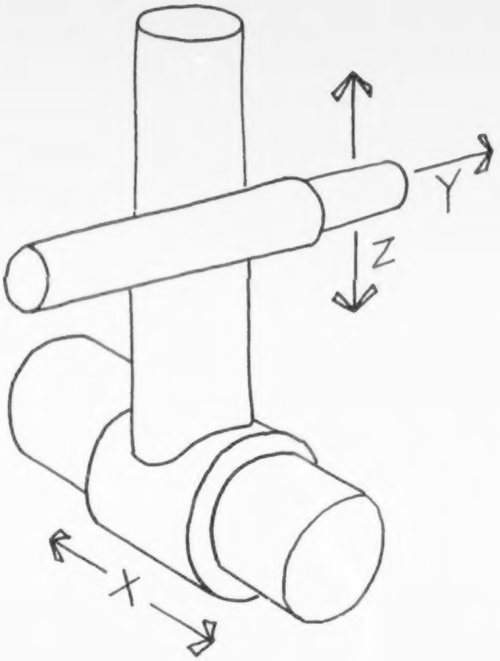
However complex the system is, each type of robot consists of four primary components. These are (1) the *manipulator*, or arm, which does the work; (2) the *controller*, which provides the control commands to the machine; (3) the *power source*, which provides the power to the unit; and (4) the *end effectors*, which do the gripping, welding, painting, etc.

Procedure

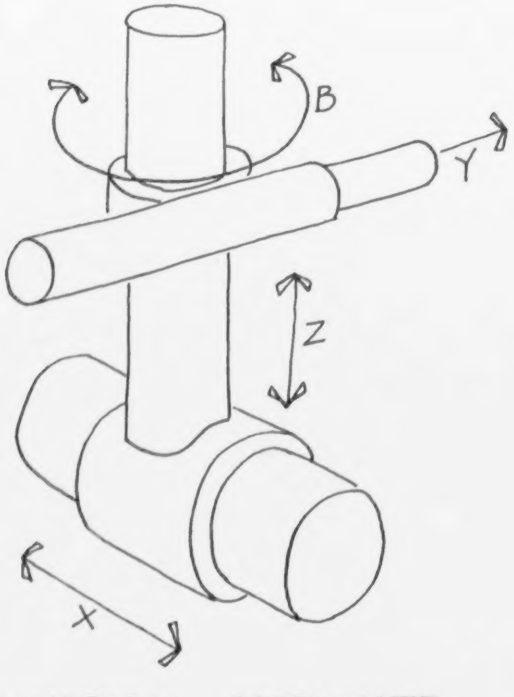
1. After you have read both the background information and introduction, your instructor will ask that you divide into small groups of two or three students. Each group is to design and draw a robotic system based on one type or any combination of the primary types listed in the activity. Your group should start by considering what function the robotic arm is supposed to perform. Your instructor will provide this information.
2. Draw a rough draft of your design on a piece of paper and label the various axes that will be needed for the specific operation. Be able to describe what type of controller system will be used and what type of end effect will be needed for the robot to do its job. Study your design carefully to insure that the axis movements will perform as needed.
3. When your group has agreed on a design, draw the final copy on a sheet of poster board. Add enough detail to illustrate what the capabilities of your system will be. Also identify the axes of operation that your robot will use.
4. Present your design to the class for discussion. Be able to explain the operational capabilities of your robotic system. Each group will present its design in this manner and afterwards display its work for other students to view.

Evaluation

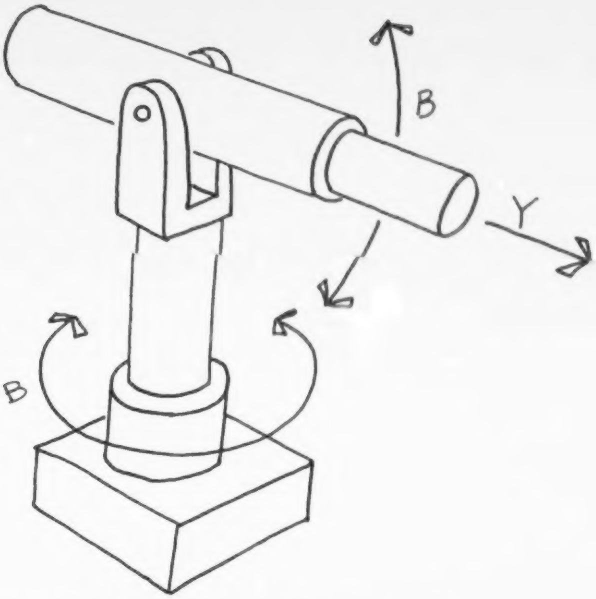
Evaluation of student performance will be based on participation in and completion of the activity.



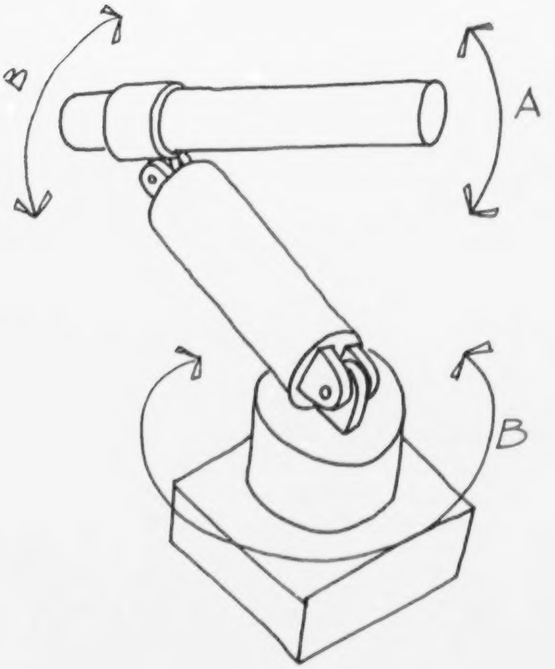
RECTANGULAR COORDINATE



CYLINDRICAL COORDINATE



SPHERICAL COORDINATE



REVOLUTE COORDINATE

(1 WEEK)

INTRODUCTION TO PROBLEM SOLVING

Essential Elements:	Common: 8-10
	Specific: 5, 11, 12
TAAS Objectives:	Math: C 1-4; O 1-4; PS 1-4
	Reading: 1-4

Activity Summary

This activity is intended to provide students with an introductory project in which they apply the basic problem-solving model to the designing and construction of a simulated structure. Students will design their structure, perform a pilot test, file a patent, and participate in a schoolwide competition.

Teaching Tips

1. Read through the entire activity and become familiar with the various sections before releasing to students.
2. Review the problem-solving model.
3. Prepare a bulletin board display to help illustrate the problem-solving process.
4. If possible, set up a competition between your school and another.

Instructional Strategy

- Lecture to present the topic to students.
- Use the problem-solving model.
- Use this activity as an individual problem-solving project.
- Use the simulation method as necessary.

Equipment/Supplies

1. 3" x 5" index cards
2. Rubber cement
3. Paper cutter
4. Scissors
5. Small fishing scale
6. Several large (1-gallon size) empty cans like those discarded by the cafeteria
7. Sand (80-lb. bag)
8. 2-5 gallon plastic paint buckets
9. Patent Application Form (included)

Evaluation Key

Evaluation will be based on participation in and completion of the activity. The resulting projects will include the structure and evaluation sheets.

INTRODUCTION TO PROBLEM SOLVING

Participate in a basic problem-solving activity to design and construct a simulated structure.

Objectives

- To use the problem-solving model in the construction of a structure
- To simulate the application of construction specifications
- To perform a basic testing procedure to determine structural strength
- To develop personal skills in workmanship and precision

Vocabulary/Concepts Reinforced

- Problem solving—The systematic process of applying a set of steps, from identifying the problem to evaluating the results.
- Simulation—The process of duplicating an actual process, by means of modeling or the use of a computer program in order to test a particular concept.
- Patent—The legal means of establishing ownership of an invention for a specified number of years. The patent grants to the inventor exclusive right to make, use, or sell his or her invention.
- Live load—A variable load that may be imposed on a structure.
- Dead load—A stationary load imposed on a structure, usually a constant weight.

Equipment/Supplies

- 3" x 5" index cards
- Rubber cement
- Scissors
- Patent form
- Testing for Structural Strength form
- Sand
- Scale
- 3 or 4 1-gallon cans
- Patent Application Form
- Mailing envelope and postage stamp

Introduction

One of the most important concepts that students enrolled in Industrial Technology courses will encounter is that of the problem-solving process. Problem solving is directly responsible for many of the technological innovations that we enjoy today. Most of the things that we use on a daily basis, including televisions, cars, pocket tape players, medicines, and even Nintendo games, are direct results of people working to solve technical problems. Developing skills in this area is an important component of Industrial Technology education, and being able to understand and apply the problem-solving process is the primary goal of this activity.

The problem-solving process consists of five sequential stages designed to help organize the process. These stages include the following:

1. Defining the problem
2. Setting the goals
3. Developing alternative solutions
4. Selecting the best solution and implementing it

5. Evaluating the solution by comparing it to the original problem

Procedure

1. The first step in this activity is to define the problem. The problem actually has two parts. The first part is to design and build a structure that simulates the effects of live loads on structural interjectory. This includes designing a structure that supports a maximum live load by determining its efficiency rating and calculating the safety limit factor. The second part of the problem is to file for a patent on your design and take part in a competition to determine the structure with the greatest live load capacity.
2. The second stage in the process is to set the goals. In this stage the specifications for the solution are either established or studied to determine the next step. The specifications outline the general size and shape of the structure and limit the types of materials that can be used. The specifications for this activity are:
   - A. The total structure shall be made from no more than 4 - 3 1/2" x 5" index cards two of which will form the structural shell and the other two to form the internal structural support system.
   - B. The overall size of the structural shell shall be 3" long by 2 1/4" high by 2 1/4" wide. See figure 1.
   - C. The internal structural support shall be made from no more than 2 - 3 1/2" x 5" cards. They can be cut, folded, laminated, etc., to meet your own design, but they must be contained inside the shell.
   - D. The adhesive or bonding agent shall be rubber cement. No other bonding agent such as Super Glue or hot glue from a gun can be used.
   - E. A minimum safety limit factor of 53 ounces is necessary to qualify for the intraschool competition. Test your design so that the open ends of the shell are on the sides. The formulas for calculating the efficiency rating and safety limit factor are:

     Efficiency Rating = Weight of live load + Weight of structure

     Safety Limit Factor = Efficiency rating + 3

   - F. A patent application will be filed by each group to insure security of designs. Each team will submit a completed Patent Application Form with an attached working drawing of the design. Each patent application will be mailed to the instructor at his or her school address. The postal cancellation date will be the official filing date and all applications will be secured by the instructor. Any duplication of design will be marked as unapproved and returned.
3. The third stage of the problem-solving process is developing several possible solutions. It is rare that the solution to a problem is found on the very first try; it is more likely that developing a solution will take several attempts. At this stage it is often helpful to make several sketches to record your ideas. It is advisable to keep a folder containing your research material and to keep it secured from others who might want to duplicate what you are doing.
4. The fourth stage in the process is to select one option from the list of possible solutions and test it to determine whether or not it will function as you intended. This process, called pilot testing, is a critical part of the problem-solving process and is used extensively in technology and industry to insure successful products.
5. The fifth stage is evaluating the results and examining them against the original criteria. This will allow the designer to make any necessary modifications

before the product is completed. This stage completes the problem-solving process and should result in a completed project. The final structure should be secured until the necessary patent has been filed.

6. To file for patent protection of your project you will need to complete the patent application. Fill in all of the necessary information and complete the detailed drawing. For the filing to be legal, you must mail the application form to your instructor at his or her school address. The postal cancellation date will serve as the official filing date. Your instructor will evaluate each application and keep a record of those that are on file and cannot be duplicated. The instructor will probably want to copy the patented designs to avoid duplication problems.
7. With your patent filed and your design protected, you may now participate in a competition set up to determine which design will support the greatest live load. The winner will be the design that has the highest safety limit factor.

Evaluation

Evaluation will be based on participation in and completion of the activity. The resulting projects will include the structure and evaluation sheets.

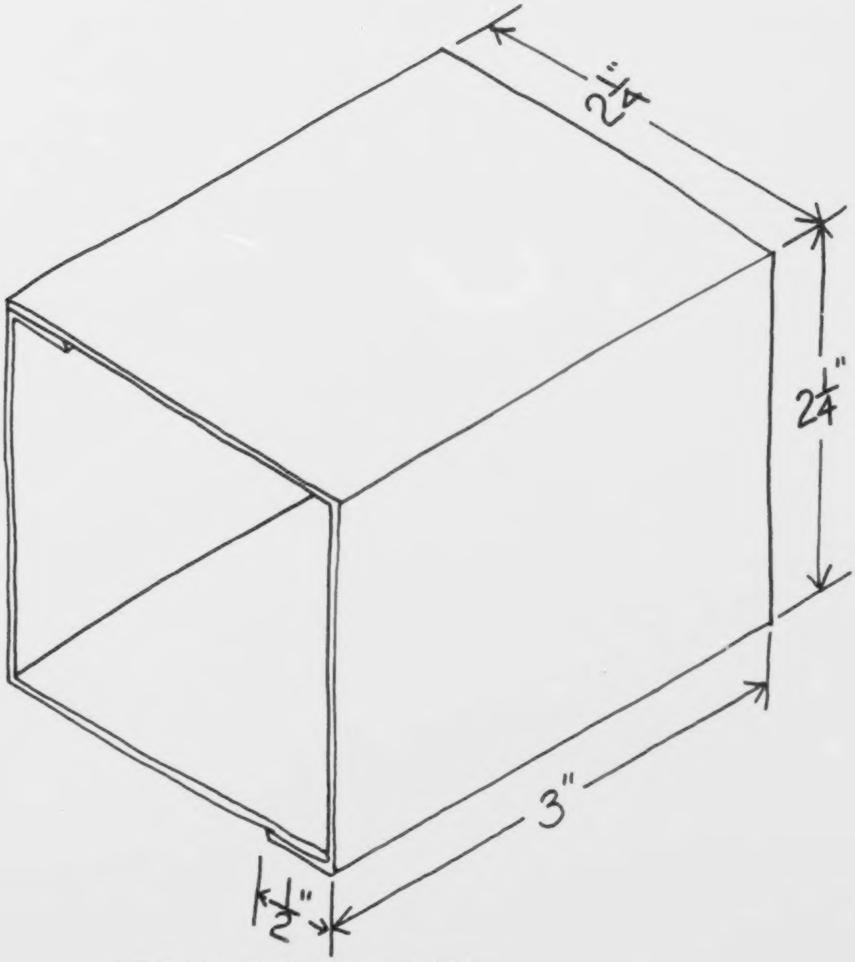
PATENT APPLICATION FORM

STUDENT NAME: ____________________ DATE RECEIVED: ________

SCHOOL: ___________________________ CLASS: _________________

NAME OF DESIGN: ____

DESIGN DETAIL: (In the space below draw the Front, Top, and Side views of your design. Include the internal support system in detail.)


$2\frac{1}{4}$"
$2\frac{1}{4}$"
3"
$\frac{1}{2}$"

STRUCTURAL SHELL

Figure 1

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 21
(2 WEEKS)

ADVANCED PROBLEM SOLVING—TEAMWORK

Essential Elements: Common: 1, 2, 6, 9, 10
Specific: 5, 10, 12, 13
TAAS Objectives: Math: C 1-4; O 1-4; PS 1-4
Reading: 1-5

Activity Summary

This activity is intended to introduce the concept and practice of teamwork into the problem-solving process. Students will work in groups of three or four to design and construct a tower and then test it for structural strength. Students will use the problem-solving model to help accomplish the activity.

Teaching Tips

1. Read through the activity before releasing to students.
2. Discuss the importance of teamwork with your students and stress the use of teamwork in industry.
3. Cover any necessary safety rules regarding equipment and tools to be used.
4. Set a deadline for completion of the activity. This should be the date of the competition between student groups to determine the strongest tower.
5. Consider opening the activity up to the entire school. This could involve students who have not yet had an opportunity to take any of the Industrial Technology courses.
6. Build the testing platform by using an 8" square of 3/4" plywood with a 1"dowel secured in the center. The dowel should be at least 24" tall above the surface of the platform. (See attached detail.)
7. Cover the specifications very carefully with the students before issuing them any of the materials.

Instructional Strategy

- Lecture to present the topic to students.
- Use the problem-solving model as a basis for this project.
- Use the teamwork concept.
- Encourage the use of brainstorming.

Equipment/Supplies

1. Balsa wood
2. White (Elmer's) glue
3. Material for test stand
4. Weights
5. Scale
6. Miscellaneous drafting materials
7. Testing stand

Evaluation Key

Evaluation will be based on participation in and completion of the teamwork project.

ADVANCED PROBLEM SOLVING—TEAMWORK

Work in groups to solve a structural design and construction problem.

Objectives

- To develop basic teamwork skills to solve a technical problem
- To construct a structure based on a given set of design specifications
- To develop skills in precision measurement and assembly

Vocabulary/Concepts Reinforced

- Teamwork
- Design specifications
- Precision
- Workmanship

Equipment/Supplies

- Balsa wood
- White (Elmer's) glue
- Scale
- Miscellaneous drawing materials
- Testing stand and weights (provided by instructor)

Introduction

Industry relies heavily on teamwork to help solve technical problems. Many industries use the team approach through project teams, committees, product groups, or think tanks to solve technical problems. Teamwork is important because it takes advantage of the special skills and talents of each individual in the team. Industry builds effective teamwork with strong individuals who understand the importance of the team effort. It is important, therefore, for students involved in Industrial Technology classes to gain experience in problem solving through a team approach.

In this activity students will work in groups of three or four to design and construct a tower using a set of specifications provided by the instructor (see illustrations). Each group will then compete with other teams to determine which has designed and built the strongest tower. Success or failure in completing this project depends a great deal on each person's cooperation and resourcefulness.

Procedure

1. Begin by dividing the class into groups of three or four students as needed.
2. Each group should read the specifications for the tower, then discuss the general scope of the project in order to understand precisely what your limitations are.
3. Make a note of the deadline date. This is the date for completion of all work on your tower. Keep in mind that you will need ample time to build at least one prototype.
4. Meet as a group and brainstorm as many design ideas as possible. It is a good idea to have one member of the group keep a record of the group's ideas. Don't

rule out too many of the ideas at this point as long as they meet the design specifications.

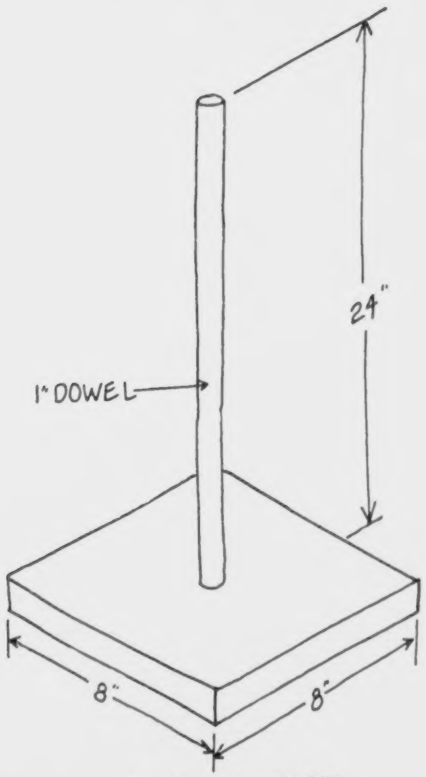
5. Use the drawing and drafting equipment provided by your instructor to begin the design sequence. One point to remember as you begin is that precision and accuracy, coupled with quality workmanship, yield the best results.
6. As your group begins to develop design ideas it is advisable to build sectional prototypes to better gauge the strength of individual components. Pay particular attention to joints and connection points.
7. Another important aspect that your group should consider is the security of your design. Any prototype testing should be done in a secure area where others will not see what you are doing.
8. When your group feels that the design is perfected, it is time to build the finished product. Remember that craftsmanship and precision are probably the most important elements of the structural strength of the tower.
9. On the date designated by your instructor, all groups should compete to determine which tower supports the heaviest load.

Specifications

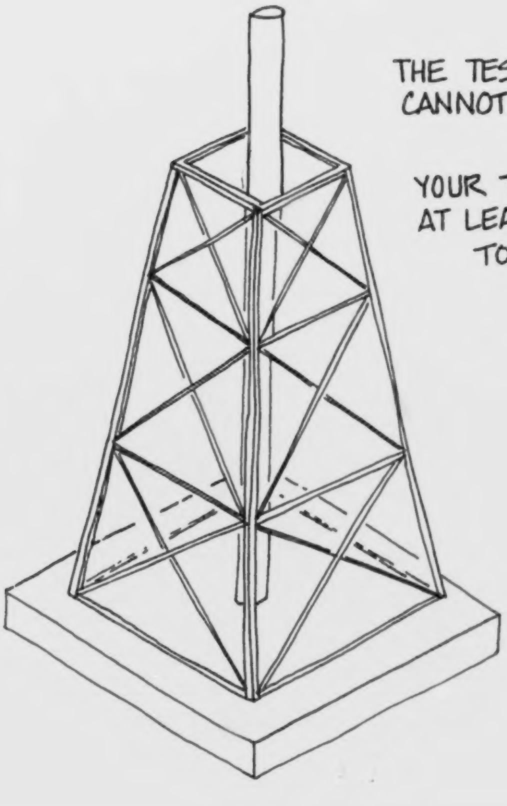
- Materials shall be limited to balsa wood and white (Elmer's) glue.
- No Super Glue, string, tape, wire, or other material will be used.
- The base of the tower must fit onto the eight-inch-square base of the testing tower.
- The tower must be at least 13 inches high but not more than 14 inches.
- A clear opening must be designed into the structure to allow for a one-inch-thick dowel to pass without touching any part of the tower.
- The uppermost surface of the tower must be flat to accommodate the testing weights. Design and build the top surface to be at least 1 1/2" square. This will provide a steady surface for the weights.
- The weight of the tower cannot exceed one ounce. The instructor will weigh each tower on the day of the competition.
- On the day of the competition the instructor will inspect each tower to verify compliance with specifications and keep it secure until its turn for testing.

Evaluation

Evaluation will be based on your participation in and completion of the teamwork project.

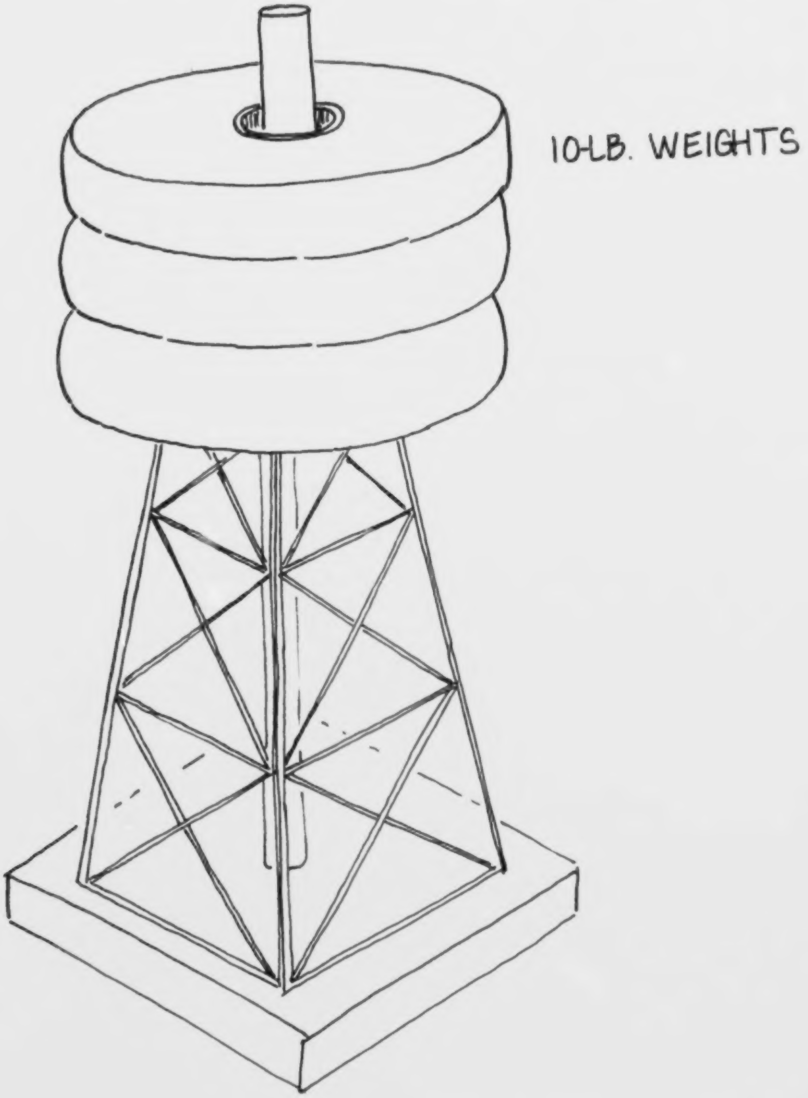


TESTING BASE



THE TESTING BASE DOWEL CANNOT TOUCH THE TOWER.

YOUR TOWER SHOULD HAVE AT LEAST A 3½" SQUARE TOP SURFACE.


10-LB. WEIGHTS

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 22
(2 WEEKS)

DETERMINING RAFTER LENGTHS FOR ROOF CONSTRUCTION

Essential Elements: Common: 2, 8
Specific: 2, 13
TAAS Objectives: Math: C 1-5; O 1, 2; PS 1
Reading: 1-6

Activity Summary

This activity is intended to help students understand the use of technical charts to determine structural data for construction. The particular chart used here is an easy reference for determining rafter length from span distances and roof pitch information. Students will be given a series of problems in which they will use the chart to determine various rafter lengths.

Teaching Tips

1. Read through the entire activity and become familiar with the material before releasing to students.
2. Discuss with students the use of visual charts and graphs which are available to help production workers in a variety of work-related activities.

Instructional Strategy

- Lecture to present the topic to students.
- Use graphic information to help communicate technical data.
- Use the problem-solving technique.

Equipment/Supplies

1. Conversion chart
2. Student worksheets
3. Calculator
4. Scratch paper

Evaluation Key

Evaluation will be based on participation in and completion of the activity. Use the following evaluation key to check student responses to worksheet questions.

1. 26'
2. 12'
3. 29'
4. 15'
5. 18.6'
6. 13 rafters 26' long
7. 12 rafters 15'6" long
8. 8/12
9. 23'6"
10. 20'6"

DETERMINING RAFTER LENGTHS FOR ROOF CONSTRUCTION

Use a reference chart to determine various rafter lengths for a series of different spans.

Objectives

- To use graphic reference charts to determine specific technical information
- To use an architect's scale to measure and scale accurate distances

Vocabulary/Concepts Reinforced

- Rafter—A structural member used to support roof loads. The sizes of rafters are determined by span distance and load forces on the roof.
- Roof pitch—This refers to the slope or angle of the roof.

Equipment/Supplies

- Student worksheets
- Conversion chart
- Calculator
- Scratch paper

Introduction

In the construction industry many reference charts are used to determine a variety of technical information. One such chart is the conversion chart for calculating the lengths of rafters needed to span certain distances. This chart is useful because it saves both estimators and carpenters time in determining rafter lengths.

Procedure

Familiarize yourself with the conversion chart and work the following problems based on the information given and the reference chart. Compare your answers to others in the class. Discuss the effectiveness of using conversion or reference charts in a production setting.

Evaluation

Evaluation will be based on participation and on completion of the activity and the worksheet questions.

STUDENT WORKSHEET

1. Find the length of a rafter if the span is 24 feet and the roof pitch is 5/12.
2. Find the length of a rafter if the span is 10 feet and the roof pitch is 8/12.
3. Find the length of a rafter if the span is 25 feet and the roof pitch is 6/12.
4. Determine the horizontal span for a rafter whose length is 18 feet and the roof pitch 8/12.
5. Find the length of a rafter if the span is 17 feet and the roof pitch is 5/12.
6. If a space measures 26 feet long and 24 feet wide with the ridge running down the center of the length, how many rafters would be needed if spaced 24 inches on center? What would be the length of each rafter if the roof pitch is 5/12 and each has a 24-inch tail?
7. Find the number and lengths of rafters required to build a shed roof for a patio when the patio is 14 feet wide and 24 feet long. Note that the overhang on the ends and the side is 1 foot and spacing is 24 inches on center. The pitch is 3/12.
8. What is the roof pitch for a roof with rafters that are 20 feet long and a span of 16 feet?
9. Find the length of a rafter when the roof pitch is 6/12 and a span of 21 feet.
10. Find the length of a rafter when the roof pitch is 5/12 and the span is 17 feet with 24-inch tails.

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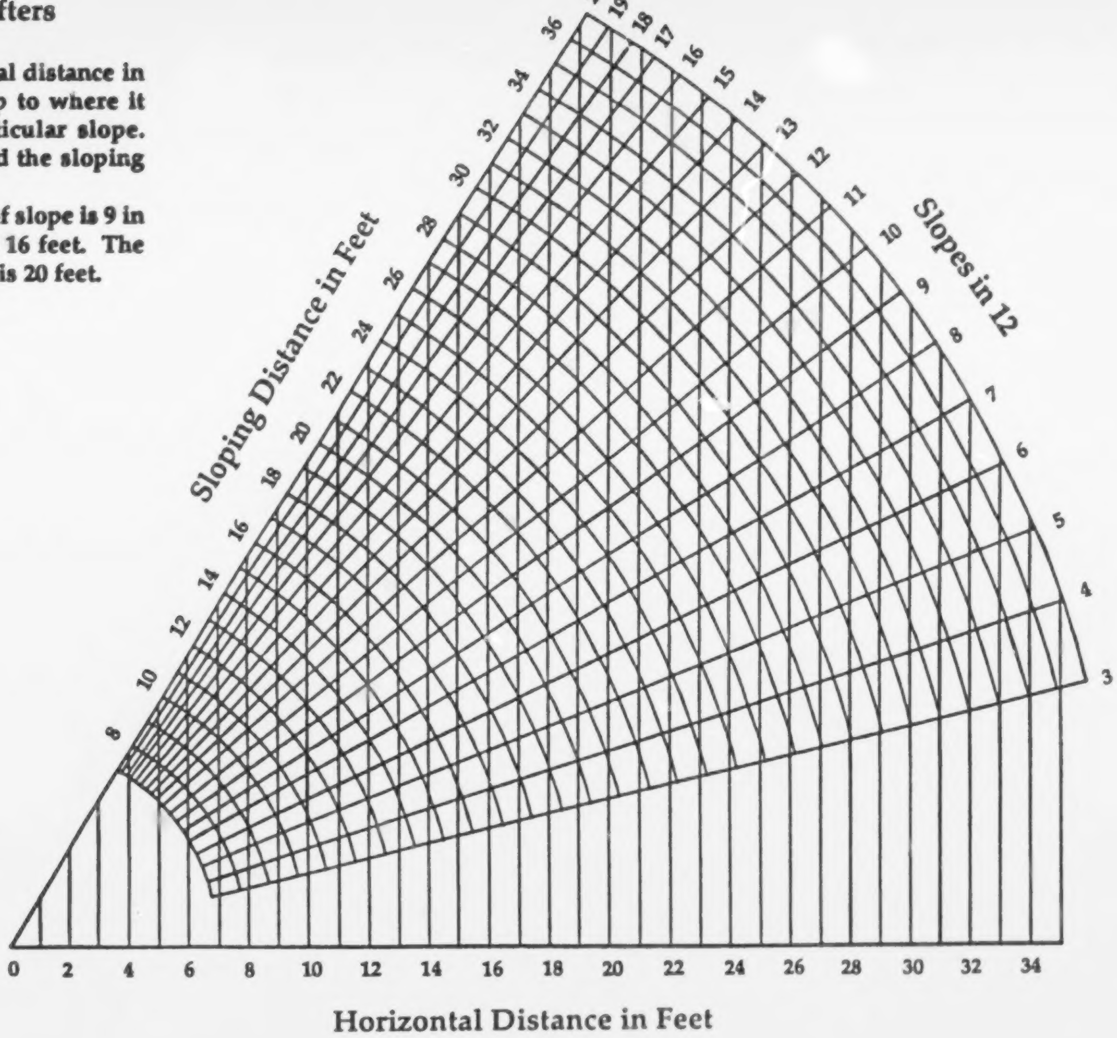
Conversion Chart for Rafters

To use the chart, find the horizontal distance in feet, then follow the vertical line up to where it intersects with the line for the particular slope. From this point, follow the arc to find the sloping distance in feet.

For example, you know that the roof slope is 9 in 12 and that the horizontal distance is 16 feet. The chart shows that the sloping distance is 20 feet.



PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 23
(1 WEEK)

CONCRETE DESIGN AND CONSTRUCTION

Essential Elements: Common: 1-3, 6-10
Specific: 2-4, 8-10, 12, 13
TAAS Objectives: Math: C 1-4; O 1-4; PS 1-4
Reading: 1-5

Activity Summary

This activity is intended to provide students with a team project in which they design and construct something out of concrete. These products may be stepping stones, benches, sidewalk sections, or perhaps some minor concrete repair work needed around the school campus. Students should be allowed to prepare the subsoil, build forms, mix and pour the concrete, and finish the concrete surface.

Teaching Tips

1. Read through the entire activity and become familiar with the topic before releasing to students.
2. Create a bulletinboard display related to concrete construction.
3. Show a filmstrip, video, etc., about working with concrete.
4. Have a foundation contractor talk to your students about concrete work.
5. Review safety procedures as necessary.
6. Use this activity as a money-making project if possible.

Instructional Strategies

- Use this activity as a small group project.
- Use the simulation method as necessary.
- Lecture to present the topic to students.
- Demonstrate the various tools and procedures as necessary.

Equipment/Supplies

1. Several bags of concrete mix as needed (Sakrete)
2. Form material as necessary
3. Wire mesh
4. Concrete mixing box or wheelbarrow
5. Concrete finishing tools as needed
6. Load of damp sand

Evaluation Key

Evaluation will be based on participation in and completion of the project.

CONCRETE DESIGN AND CONSTRUCTION

Design and construct a concrete product.

Objectives

- To develop an understanding of concrete as a construction material
- To work design and construct a concrete product
- To learn the basic terminology associated with concrete systems
- To calculate the volume of concrete needed for a product

Vocabulary/Concepts Reinforced

- Concrete—Concrete is a mixture of portland cement, water, and aggregates which, when mixed in the proper proportions, forms a very strong structure. Concrete strength is rated in pounds per square inch.
- Placing concrete—This usually refers to the pouring of concrete.
- Concrete finishing—Refers to the various steps in finishing the surface of the concrete after it has been poured.

Equipment/Supplies

- Several bags of dry cement as needed
- Form material as required
- Wire mesh
- Concrete mixing box or wheelbarrow
- Miscellaneous finishing tools
- Damp sand for casting

Background Information

Concrete is a common construction material made from portland cement, clean water, and aggregates. When mixed together in proper proportions, the resulting concrete forms a very strong product. Concrete is used in a variety of construction applications, from foundations for buildings to park benches.

The first ingredient is portland cement, which is made from a mixture of crushed limestone, silica, iron oxide, and alumina. This mixture is treated under high heat in a special rotary kiln to about 3000 degrees. After it has been removed from the kiln, gypsum is added and this blend is ground into a very fine powder which is then shipped in bags containing one cubic foot, or about 94 pounds, of cement.

The second ingredient is the aggregate. Aggregates are classified as either fine or coarse. When fine aggregate is specified, clean sand is usually mixed with the concrete. The size of the sand particles can range from 1/4" down to dust size. Coarse aggregates are much larger and range in size from about 1/4" to 1 1/2" in diameter. A standard 4" thick slab will usually contain aggregates of about 1" in size.

The third ingredient is water, which should be clean and free of impurities. A good rule of thumb for water that will be mixed with concrete is that it should be fit to drink. Mixing the right amount of water depends on the particular mix of concrete being made. It is important, however, not to use too much water. Although it may be easier to handle and finish, the resulting concrete will be weak and might crack under pressure.

Concrete can be purchased in a variety of forms. You can buy the ingredients separately and mix the concrete yourself or you can buy the dry ingredients already mixed together. These dry ready-mix bags are sold at most lumberyards and contain about 2/3 of a cubic foot of concrete. Each bag weighs about 90 pounds and all you have to do is mix in the right amount of water. Another way to purchase concrete is to order it from a concrete supplier who will deliver it to your school in a special concrete mixing truck. Unless your class is going to use at least one cubic yard of concrete, however, it is not economical to purchase it in this manner.

Procedure

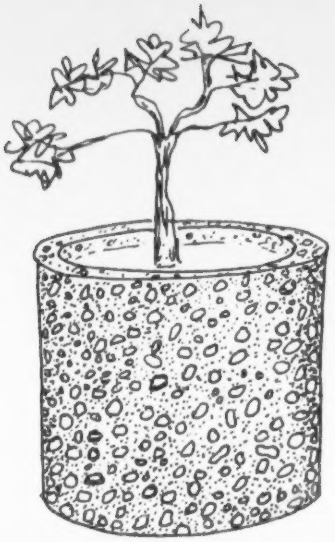
After you have read the above information and have observed the teacher's demonstration for handling concrete, look through the following ideas or design your own a class, team, or individual project. Construct your project and enjoy working with concrete. When you are through, discuss some of the things that you and your classmates learned about the properties of concrete.

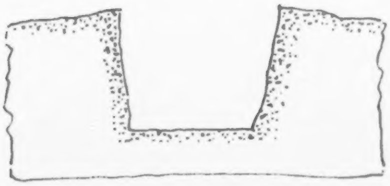
Evaluation

Evaluation will be based on participation in and completion of the project.

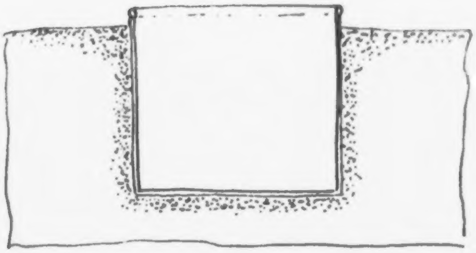
CONCRETE PLANTER

SAND-CASTING METHOD

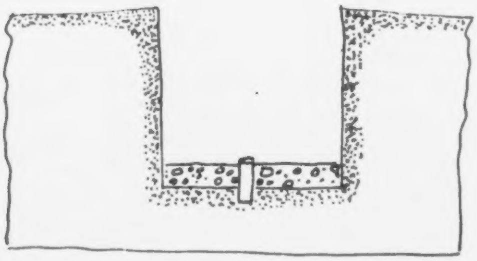




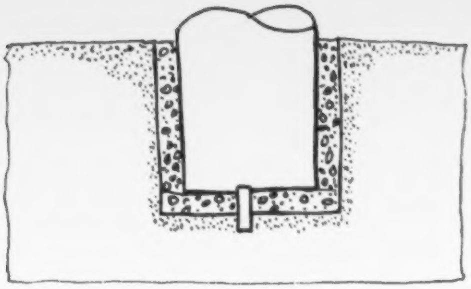
A. SCOOP OUT THE BASIC SHAPE IN A PILE OF DAMP SAND.



B. USE A BUCKET OR OTHER SHAPE TO FINISH THE FORM. AN EMPTY 5-GAL. PAINT BUCKET WORKS WELL FOR THIS SHAPE.

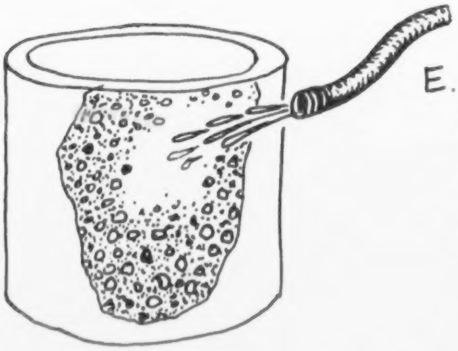


C. TO MAKE A DRAIN HOLE PLACE A SMALL AMOUNT OF CONCRETE IN THE BOTTOM OF THE MOLD. INSERT A GREASED 1" DOWEL THROUGH THE CONCRETE INTO THE MOLD.

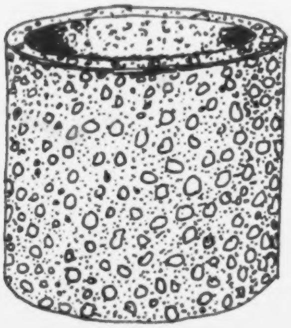


D. SET AN INNER FORM WHICH WILL ALLOW FOR SIDES OF ABOUT 2". POUR MIXED CONCRETE AROUND THE INNER FORM.

NOTE: IF YOUR MOLD IS AS LARGE AS A 5-GALLON BUCKET, IT WILL BE NECESSARY TO USE WIRE MESH TO REINFORCE THE CASTING.

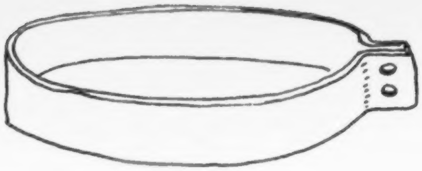


E. AFTER THE CONCRETE HAS BEEN ALLOWED TO SET FOR SEVERAL MINUTES, CAREFULLY REMOVE THE CASTING FROM THE MOLD. GENTLY WASH AWAY THE SMOOTH SURFACE TO EXPOSE THE AGGREGATES.

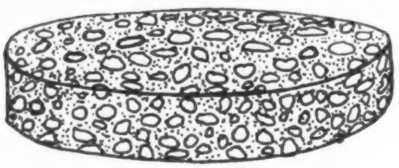


F. ALLOW FINISHED CASTING TO DRY FOR 24 HOURS BEFORE USING.

CONCRETE STEPPING STONES

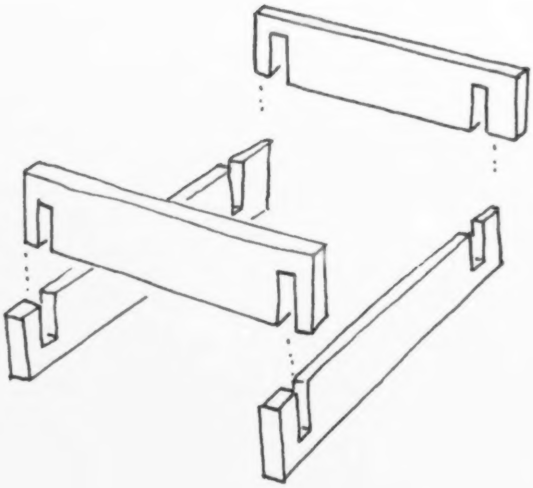


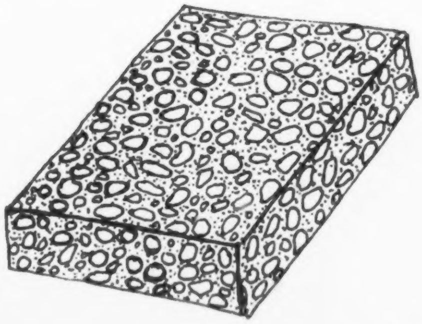
A. MAKE A REUSABLE FORM WITH 22-GAUGE GALVANIZED SHEET METAL. THE FORM SHOULD BE ABOUT 2½" HIGH.



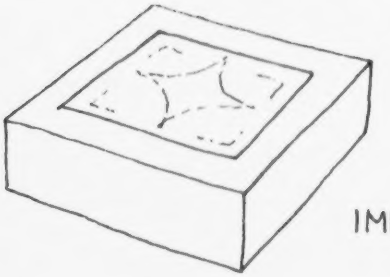
B. POUR AND WASH CONCRETE TO EXPOSE AGGREGATES.

A REUSABLE SQUARE OR RECTANGULAR FORM CAN BE MADE FROM NOTCHED 1X4 MATERIAL.





SURFACE DECORATIONS CAN BE ADDED BY IMBEDDING OBJECTS IN THE CONCRETE.



IMBEDDED CERAMIC TILE

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 24
(1-2 WEEKS)

BUILD A STRUCTURAL FRAMING MODEL

Essential Elements: Common: 1-3, 5-10
Specific: 1- 4, 9, 10-13
TAAS Objectives: Math: C 1-4; O 1-4; PS 1-4
Reading: 1-5

Activity Summary

This activity is intended to introduce students in the Production Systems course to basic structural framing by having them build a framing model. Students will work in groups of three or four students each to build sections of a house that will fit together to form the entire house when complete. Students will learn the general terminology and structural framing systems used in general residential construction. Additionally, the instructor may have students simulate other construction phases, such as electrical wiring, insulation, Sheetrock, etc.

Teaching Tips

1. Read through the entire activity and become familiar with the topic before releasing to students.
2. Create a bulletinboard display which helps to illustrate the topic.
3. Build full-scale framing sections including tees, corners, plates, etc., for students to view.
4. Select a design which best meets the needs of your students. More advanced students should be allowed to complete a more complex model.
5. Discuss the work of carpenters and other construction workers who build houses. Talk about individual responsibilities, workmanship, knowledge of materials and processes, etc.
6. Discuss with your students the variety of materials used in the framing construction processes. Tell them why some materials are considered structural materials and others are not.
7. Review safety procedures for various hand tools and machines as necessary.

Instructional Strategies

- Lecture to present the topic to students.
- Use the simulation and modeling technique to complete the activity.
- Use group or teamwork techniques with your students.

Equipment/Supplies

1. Set of construction plans for a residential structure
2. 1/4" untempered Masonite cut to sizes of various framing members
   Note: The recommended scale is 1"= 1'-0".
3. Hot glue guns and glue sticks
4. Set of blue lines for each group
5. Foundation base sections for each group. These can be made from 1/2" plywood which is cut to form the complete foundation when assembled.
6. Use miscellaneous materials to simulate plumbing, wiring, HVA/C ducts, windows, Sheetrock, insulation, etc., as needed.

Evaluation

Evaluation of student performance should be based on participation in and completion of the activity. The instructor may also want to base some of the evaluation on how well each group's section of the model fits together with the other sections.

BUILD A STRUCTURAL FRAMING MODEL

Work with a set of actual house plans to build a model framing project.

Objectives

- To read a set of construction plans for a typical residential structure
- To estimate the quantities of framing materials needed to construct a residential structure given a set of design drawings
- To work in teams to construct a model simulation of a structure
- To learn the terminology associated with residential framing construction

Vocabulary/Concepts Reinforced

- Wall framing—Wall framing makes up the interior and exterior wall sections. These walls, some of which are load-bearing walls, need to be strong enough to support the weight of the house but must also support lateral forces such as wind.
- Studs—The vertical members that make up most of the framing. They are usually made from kiln-dried yellow pine and have been treated with a waxlike coating which helps to repel moisture. The most common size stud is the 2-by-4; however, some wall sections require 2-by-6 studs. Stud spacing varies from 12" centers to 16" centers for most construction.
- Corners and tees—At the corners of all interior walls a nailing edge must be provided for the installation of Sheetrock. If two full-length studs are nailed together with three spacers between them, a third stud (the last one on the end of a wall section) can be nailed to them to form either a T shape at a wall intersection or an L shape at an exterior corner. See figure 1.
- Top and bottom plates—At the bottom and top of the stud wall sections are long framing members called plates. These hold the studs in place. The bottom plate is usually connected to the foundation by anchor bolts. The top plate is usually doubled with notches cut into the top plate to allow intersecting walls to be tied together. See figure 2.
- Door and window openings—Rough openings for both doors and windows are framed into wall sections based on the specifications supplied for the types of doors and windows being used. To support the load of the wall a special framing member called a header is installed over the opening directly under the top plate so that the bottom edge of the header is 6'8" above the floor level. Double 2-by-12 headers are used over exterior openings and double 2-by-6 headers are used over interior openings (figs. 4 and 5).
- Corner bracing—Each main corner of a structure should be strengthened with a corner brace. Corner braces are either 1-by-4 material cut into the outside of a wall section or a 2-inch metal strip which runs from the top of a corner down diagonally to the bottom plate. This type of corner brace needs to cross at least three studs. In some cases a sheet of plywood is used as a bracing material.
- Ceiling joist—In construction where roof trusses are not used, a ceiling joist is used to tie exterior and interior walls together. The size of a ceiling joint depends on the span, type of wood, and spacing.
- Roof truss—These are generally engineered members which are designed to evenly distribute the roof load onto the exterior or load-bearing walls. Roof trusses are available in many different layouts depending on the style of the roof and the span requirements. Roof trusses are usually designed to be spaced at 24-inch centers. Roof trusses are most often built in an automated truss mill and save the builder both time and materials when compared to conventional framing techniques.

Equipment/Supplies

- Set of house plans

- 1/4" untempered Masonite
- Hot glue gun and several glue sticks
- Small combination square
- Foundation base (provided by teacher)
- Table saw for cutting sheets of Masonite

Background Information

Typical residential framing is the process of building the skeletal structure of walls, ceilings, and roof areas. Framing must be done in accordance with strict building codes, which are usually monitored by local governmental agencies. Careful assembly of all the components insures that the structure is safe and will provide many years of homeowner satisfaction even under extreme weather and other environmental conditions.

There are several framing techniques, but the one most often used with residential construction is called platform framing. In this type of construction the walls are built on top of a platform, such as a concrete slab or framed floor area. The walls are assembled, raised into place, and secured using the top plates to interlock each section. The bottom plates are secured to the slab or second-floor framing with nails or with anchor bolts.

The first step in the framing process is to estimate the quantity of materials needed to build the structure. It is important to have a well-drawn house plan which is neat and easy to read. Dimensions and details must be clearly understood. In some cases an estimator may have already completed a materials take-off to determine the construction costs; however, many framing contractors like to complete their own take-off to insure that the correct grade, size, and quantity of materials have been ordered.

When the foundation has been poured and is ready for construction, the framer will begin laying out each wall section, identifying openings for both doors and windows. While the layout is taking place, one or two members of the framing crew will begin building the tees, corners, and header sections that will soon be needed (see fig. 1). Note that the framing crew depends on efficient teamwork to complete its job. The lead framer is a knowledgeable carpenter who knows the proper techniques for layout, cutting, and assembly of the many different framing members.

Each wall section, with its partition openings framed in, is raised into place, checked for squareness, and nailed together (see figs. 2, 4, and 5). All walls should be securely fastened to the foundation and the top plate keyed into intersecting walls as necessary. The resulting assembly of vertical walls should be relatively strong with little or no bracing to help hold them in place.

The next section to add is the roof (see fig. 3). The roof is sometimes thought of as the fifth wall, and once it has been added, rough framing is complete. Many roof designs allow for the use of prefabricated trusses. Trusses are engineered framing components that are made up of one or more triangles. They are designed to transfer both the dead and live loads to the outer walls of the structure, thus allowing for greater interior design flexibility. Conventional hand-framed roof designs, on the other hand, require interior load-bearing walls to be located in particular places to support the roof. Another advantage of trusses is that they require little or no on-the-job work other than being lifted into place and braced. Most trusses are built in a truss mill and are ordered ahead of time to be ready when needed.

After the rough framing is complete, the carpenters will add the exterior sheathing, roof decking, windows, exterior doors, siding, and as much of the exterior trim as can be done without the masonry being in place. While this drying-in process is taking place, the electrician, plumber, and heating and air-conditioning contractors will be scheduled to do some of their rough-in work.

Procedure

After you have read the above background information and discussed the framing process with your class, you can begin building the framing model. Your instructor has selected a house plan which has been divided into sections. Each section will be given to a team of students who are to simulate the work of a framing crew. One group of students can be assigned to simulate a truss mill and this group will build the trusses for the house.

When the student groups have been selected, each one should study its plans carefully. Check dimensions to insure their accuracy and take notice of any special framing situation that may not be typical of standard framing technique. After studying the plans, complete a materials take-off for studs, plates, headers, tees, corners, wind braces, cripples, etc. Note that stud spacing should be on 16" centers for a one-story house and 12" centers for the bottom floor of a two-story house.

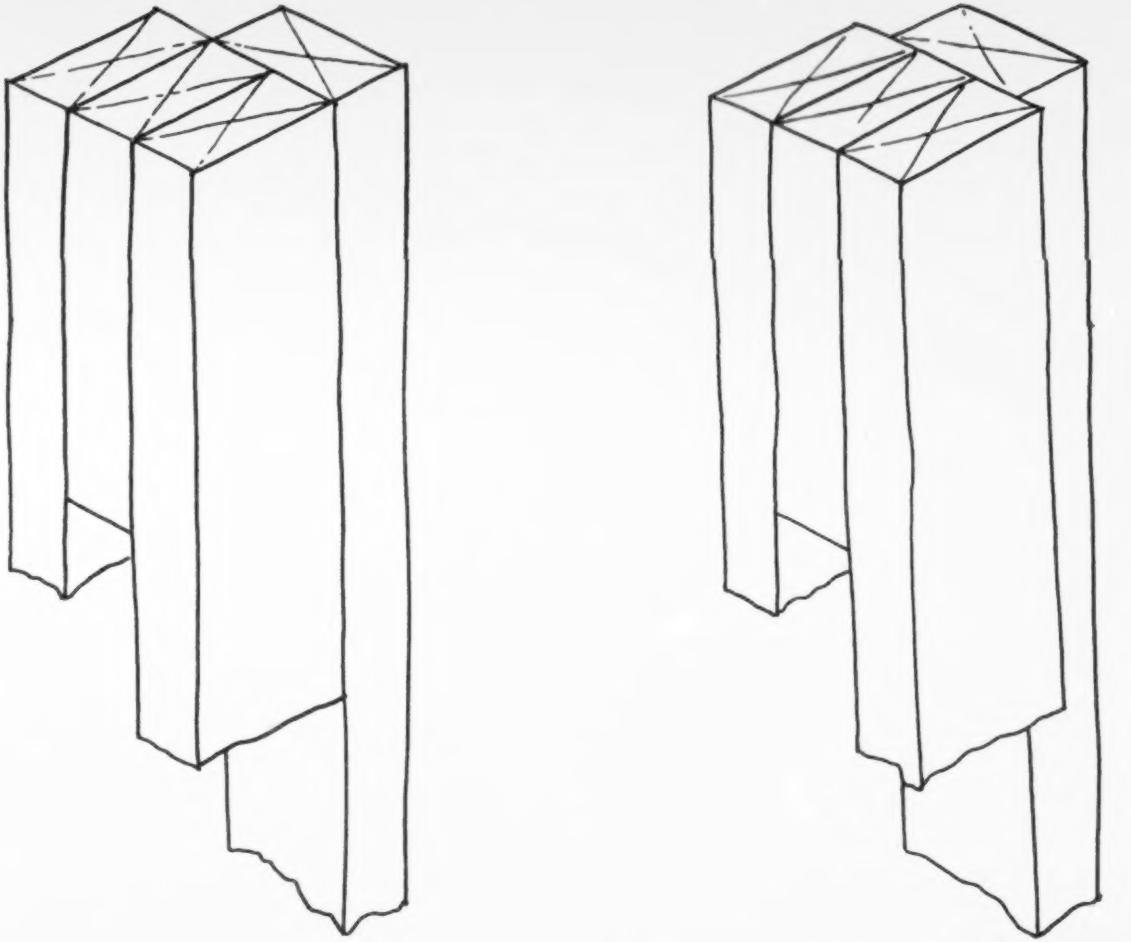
After the take-off has been completed, begin to assemble your materials. While some of the group members gather the framing materials needed for the project, others can begin laying out the wall sections on the foundation. Accuracy is very important. Be careful with your layout because the section of the house that your group is working on needs to fit into those being built by the other groups.

When the framing sections have been completed, they should match each adjoining section. While these sections are made ready for matching, the roof trusses should be fitted onto the top plate and braced. If time permits, the class can then add roof decking, simulated windows, Sheetrock, etc.

When it is finished, the entire project should be placed on display for other students to see.

Evaluation

Evaluation will be based on participation in and completion of the activity. Some of the evaluation may be based on how well each group's section of the model fits together with the other sections.



CORNER ASSEMBLY

TEE ASSEMBLY

Figure 1

TYPICAL WALL SECTION

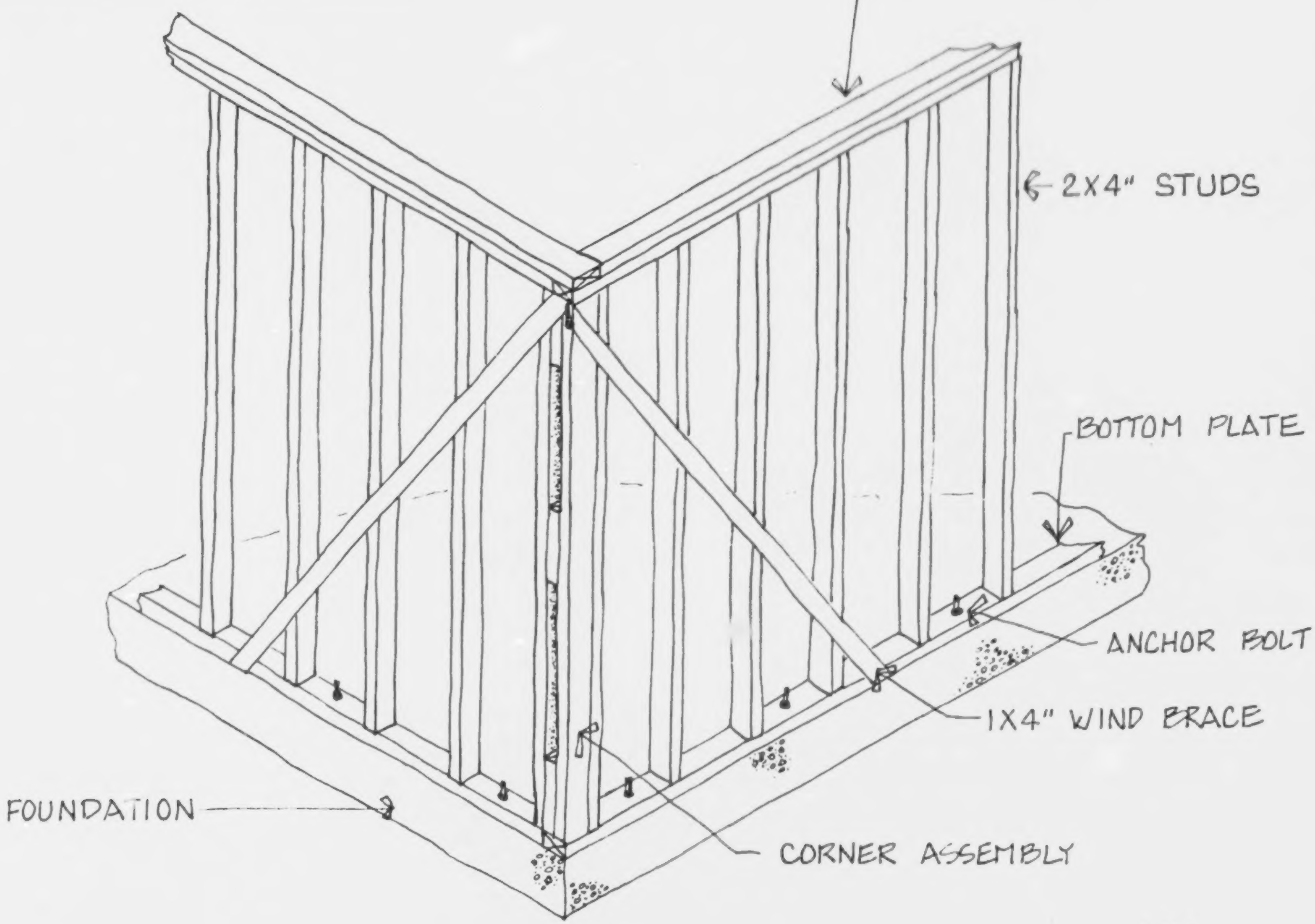

DOUBLE TOP PLATE
2X4" STUDS
BOTTOM PLATE
ANCHOR BOLT
1X4" WIND BRACE
FOUNDATION
CORNER ASSEMBLY

Figure 2

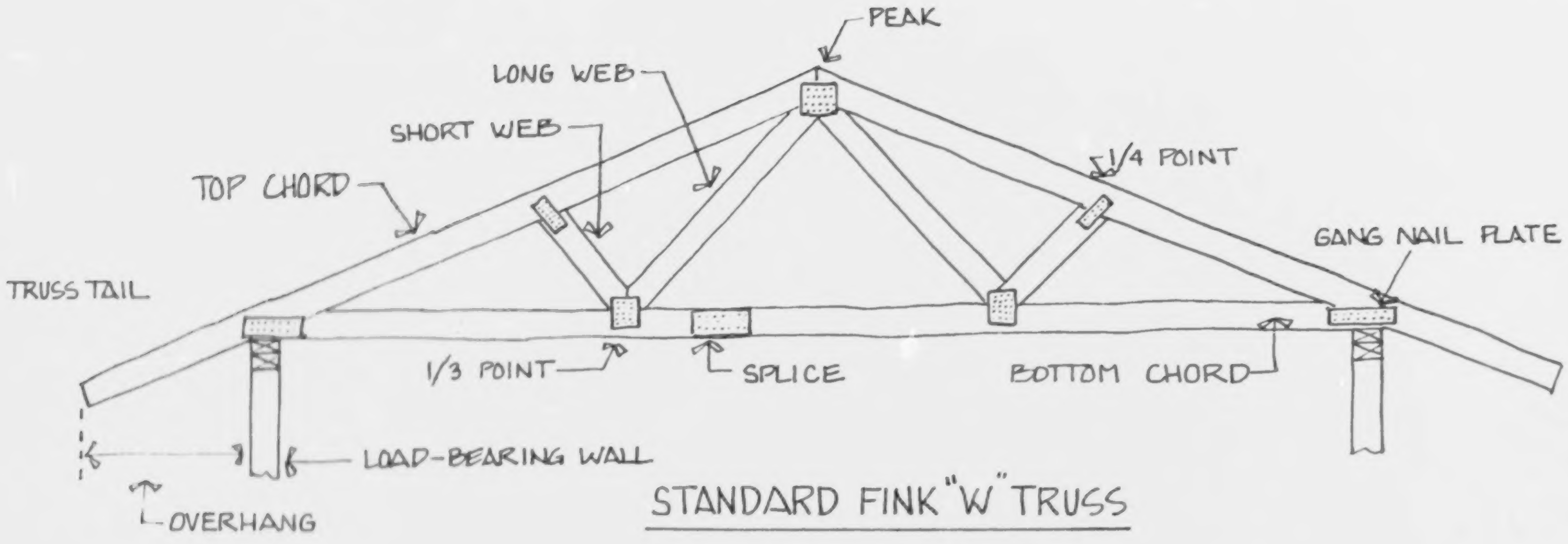
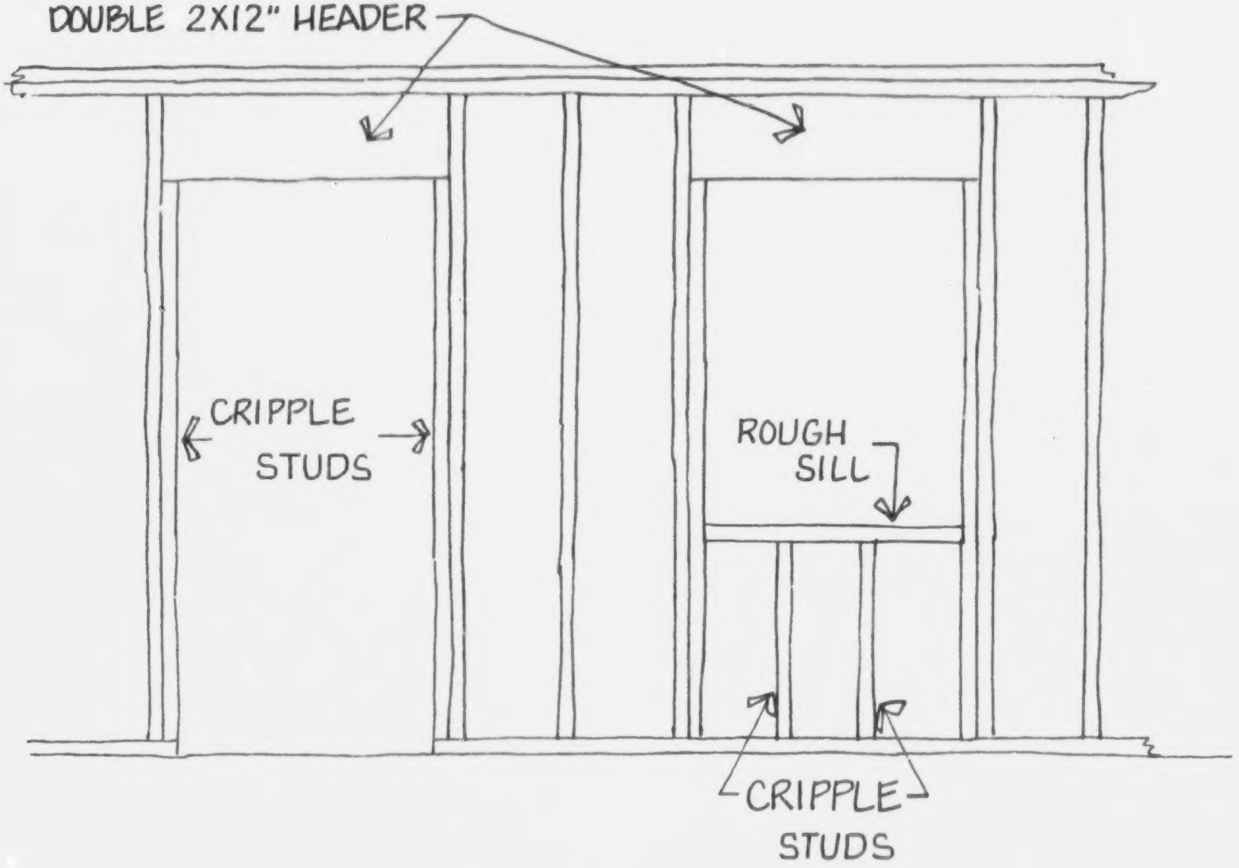
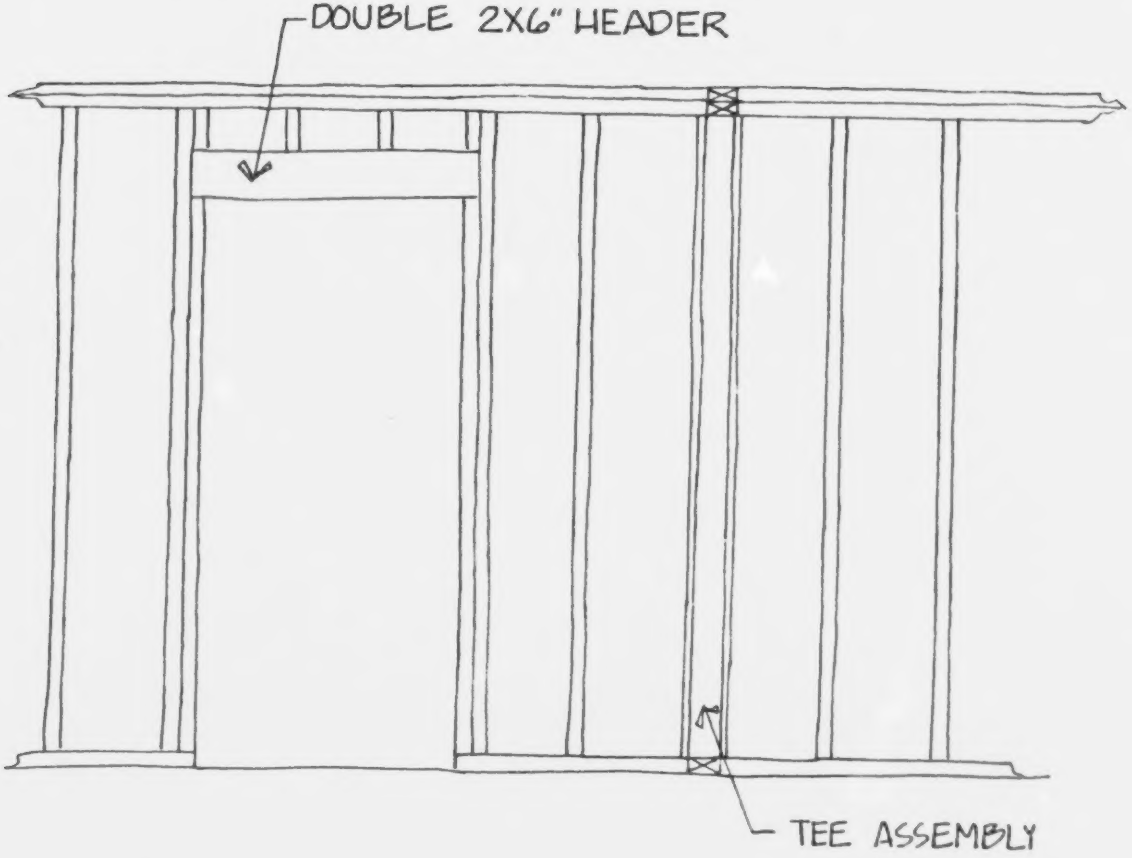

PEAK
LONG WEB
SHORT WEB
1/4 POINT
TOP CHORD
GANG NAIL PLATE
TRUSS TAIL
1/3 POINT
SPLICE
BOTTOM CHORD
LOAD-BEARING WALL
OVERHANG
STANDARD FINK "W" TRUSS

Figure 3


DOUBLE 2X12" HEADER
CRIPPLE STUDS
ROUGH SILL
CRIPPLE STUDS

EXTERIOR PARTITION OPENINGS

Figure 4


DOUBLE 2X6" HEADER
TEE ASSEMBLY

INTERIOR PARTITION OPENING

Figure 5

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 25
(1 WEEK)

BASIC BLUEPRINT READING—ARCHITECTURAL PLANS

Essential Elements: Common: 1, 8, 9
Specific: 6-8, 10, 11, 13
TAAS Objectives: Math: C 1, 3, 4; O 1-4; PS 1-4
Reading: 1, 5

Activity Summary

This activity is intended to provide students practice in basic residential blueprint reading. Students will learn basic blueprint formats, symbols, and dimension reading.

Teaching Tips

1. Read through and become familiar with the entire activity before releasing to students.
2. Obtain several copies of commercially produced residential and commercial blueprints or blue lines.
3. Prepare a bulletinboard display which illustrates some of the concepts covered in the activity.

Instructional Strategy

- Use this activity as either a small group or individual project.
- Lecture to present the topic to students.
- Use a guest speaker from the construction industry to talk about the use of blueprint reading in construction.

Equipment/Supplies

1. Several sets of blueprints
2. Student worksheets
3. Pencils and paper
4. Architect's scale

Evaluation Key

Evaluation of student performance should be based on participation in the activity and completion of the worksheet.

BASIC BLUEPRINT READING—ARCHITECTURAL PLANS

Learn basic residential blueprint reading and become familiar with the basic symbols and dimensioning used.

Objectives

- To learn the basic symbols and dimensioning standards used in residential construction blueprints
- To identify the general types of plans used in residential construction

Vocabulary/Concepts Reinforced

- Scale—Because full-size drawings cannot be made on a sheet of paper, they are scaled down using fractions of an inch to represent 12 inches (1 foot). Generally, for a standard-size residential drawing the scale is 1/4" = 1'-0". For larger houses a scale of 1/8" = 1'-0" is sometimes used. On wall sections and other detail drawings within the set of plans, a scale of 3/4" = 1'-0" is used.
- Working drawings—The series of drawings by the architect which contain all of the typical views, symbols, dimensions, and details necessary to clearly communicate to the contractor how to build the house.
- Site plan—Shows the position of the house in relation to the property and locates north. The site plan shows all legal dimensions, including building setbacks, public utility easements, and building lines.
- Floor plan—A drawing showing a straight down (or aerial cutaway) view of the house. It is drawn to show the size and location of all walls, door and window openings, and cabinets. The floor plan usually includes all of the dimensioning, window and door sizes, and, in some cases, the electrical layout.
- Foundation plan—Shows the layout and dimensions of all the foundation beams and recesses. The foundation plan will usually have a series of beam details which illustrate the section views of the foundation.
- Elevations—Illustrate the front, side, and sometimes rear views of the house. Elevations serve to show the height of things such as doors, windows, wall sections, the roof, and other exterior details. If needed, a section view of the house will be used to help illustrate some special design feature.

Equipment/Supplies

- Set of house plans
- Student worksheets

Background Information

One of the most important functions of the design architect in designing and drawing a set of house plans is to communicate as much information as possible in a neat and understandable set of plans. In many cases the designer may never visit the construction site, so the contractor must be able to understand exactly how the house is to be constructed. For this purpose a standard set of symbols and a standard drawing technique are used to convey the necessary information to the builder. Although there may be some minor variation in drawing styles, most designers use the same set of symbols and dimensioning techniques.

Being able to read and understand architectural drawings is important to everyone involved in the construction process. One of the first persons to read and study the plans is someone in the local building inspection department. Plan reviewers study the architectural drawings for compliance with building codes. They must know how to read and analyze the various drawings and determine an assortment of information, from R-value of wall sections to the egress space of windows in bedrooms. Plan reviewers may also study framing details to insure the use of correctly sized structural members. They may also study the plans to determine correct location of the building on the property.

Lending institutions also have people who specialize in reading plans. Banks need to insure that the homes they are lending money on are designed correctly and are a worthwhile investment. Many banks even hire inspectors who check construction work for compliance with building standards. These individuals must know how to read and understand architectural specifications and details.

The various contractors involved in the actual construction, from rough carpentry to finish painting, also need to know how to read architectural plans. Contractors study blueprints initially to estimate the labor and materials needed. They must be able to read every detail associated with their particular trade in order to prepare a bid. Failure to read a plan correctly can result in cost overruns as well as poor workmanship. These are more reasons why the information provided in the plans and specifications must be complete and accurate.

Homeowners should also be able to read a set of residential blueprints. Although the typical home buyer does not usually get a set of plans in a neat homeowner's manual, he/she will usually want at least one set of plans to keep as a reference. This set of plans will be especially useful during all types of home maintenance.

Residential blueprint reading is an important component of the production world for understanding not only the actual construction work being performed but also all the related activities necessary to building a house. Being able to read and understand the various drawings and symbols is a form of technological communication and is a vital link in the production process.

Procedure

Your instructor will divide the class into small groups of three or four students. Each group will be given a set of blueprints to use as a reference when completing the following worksheet. As your group begins to work through the set of questions, draw the symbol or write down the information requested.

Evaluation

Evaluation of student performance will be based on participation in the activity and completion of the worksheet.

STUDENT WORKSHEET

1. Name the various sheets included in the set of plans which your group will use.

2. What scale is the site plan drawn to?

3. Draw the symbol used to identify the north direction.

4. Referring to the site plan again, tell how far the building set-back line is from the front property line.

5. Referring to the site plan again, do you see any public utility easements located on the site? If so, how wide are they?

6. What is the total square footage of living space in the house? (This is the area which is heated and cooled.)

7. Can you identify the window sizes based on the information given in the floor plan? If so, draw a sample symbol for the window and identify it to show its size.

8. Can you identify the exterior finish? What information from the set of plans helps to identify what is used?

9. What is the size of the entry door? Is there just one door in the unit or is there also a side lite? Draw the symbol used for the front door on the floor plan in the space below.

10. How many exterior lights are located on the front of the house? How many switches control these lights? Draw an example below of an exterior light and its controlling switch.

11. What is the pitch of the roof? How can you determine this angle based on the information given in the set of plans your group is using?

12. How high are the interior walls?

13. Are there any cased openings in the house? Draw an example of a cased opening in the space below.

14. Is there any slope to the garage floor? If so, draw the symbol used to identify the direction and amount of slope.

15. Locate the water heater. Draw the symbol used to represent the water heater.

16. Are there any wall plugs located on the outside of the house? Draw the symbol for an exterior wall plug.

17. Are there any furrdowns above the bathroom vanities or kitchen counters? If so, draw the symbol for these.

18. What is the size of the gable end vent?

19. Is there a central heating and air-conditioning closet? If so, how is this illustrated in the plan that your group is using?

20. In the kitchen, is the dishwasher located near the kitchen sink? If so, is it on the same side as the garbage disposal? Draw this section of counter space and show how your plan identifies this relationship of dishwasher and disposal to the kitchen sink.

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 26
(6 WEEKS)

DESIGN AND BUILD AN ALUMINUM CAN CRUSHER

Essential Elements: Common: 1-4, 6, 8-10
Specific: 4, 7, 10, 12, 13
TAAS Objectives: Math: C 4; O 1-4; PS 1-4
Reading: 5
Writing: 1-7

Activity Summary

Students work in teams to design and construct a device to crush aluminum cans for recycling. Each team of students will be given a set of design specifications from which they are to organize, plan, secure materials for, build, and demonstrate their device to a product evaluation committee.

Teaching Tips

1. Read through the entire activity and become familiar with the project before releasing to students.
2. Discuss basic problem-solving techniques with your students before beginning the project.
3. Use one or more of the simple problem-solving activities before beginning this activity.
4. Review safety procedures for the various machines and tools that might be used in this activity.
5. Revise the design criteria as needed to meet the needs of your students.
6. Provide an assortment of assembly materials as needed.
7. Have students present their group prototype to a group of teachers and administrators who will simulate a corporate product selection committee.
8. When the product selection committee has selected the winning design the entire class should try to market the product, take orders, and manufacture the device based on the number of orders received. This will be a good method for teaching the business end of production technology.

Instructional Strategies

- Lecture to present the topic to students.
- Use the concepts of teamwork and group dynamics for this activity.
- Use the problem-solving model as a method for completing this activity.
- Encourage creativity and innovation in presenting this topic to students.

Equipment/Supplies

1. Sets of design specifications
2. Drawing paper
3. Drawing boards, T squares, triangles, scales, etc.
4. Miscellaneous materials as needed
5. Any necessary hand tools and machines

Evaluation Key

Evaluation of student performance should be based on participation in and completion of the activity. As their instructor you may wish to include additional criteria as necessary to meet the special needs of your students.

DESIGN AND BUILD AN ALUMINUM CAN CRUSHER

Work in teams to design and build an aluminum can crusher for recycling aluminum cans.

Objectives

- To complete a group activity in which students design and construct a product based on a set of design specifications
- To pilot test a device and complete a series of design evaluations to establish performance standards on a product

Vocabulary/Concepts Reinforced

- Problem solving—The systematic process of applying a set of five sequential steps used to organize the problem-solving process. These steps include defining the problem, setting goals, developing alternative solutions, selecting the best solution, and evaluating the results by comparing them to the original problem.
- Teamwork—Using individual strengths and talents to solve complex design problems in an organized and well-planned group activity.

Introduction

As students become involved in the Industrial Technology program, they learn to apply two very important concepts, problem solving and teamwork, that will be used in a variety of project activities. These two concepts embody some of the most important processes common to technology and industry. Many of the technological processes discovered and developed over the years have not been the result of individual efforts but have been the direct result of the dynamics of teamwork and systematic problem solving.

Problem solving is certainly not a new concept to technical education, but its importance is now viewed with greater interest. Problem solving is recognized as one of the basic principles of technical education, and students should develop a thorough understanding of its application. The principles of problem solving can be used in a variety of school learning activities and should be viewed as a lifetime skill.

Problem solving is divided into five steps or stages. These five stages are organized sequentially to provide a systematic approach to solving a variety of problem types. These stages include the following:

1. Defining the problem
2. Setting the goals
3. Developing alternative solutions
4. Selecting and implementing the best solution
5. Evaluating the solution by comparing it to the original problem

Another concept that will play an important role in technical education is that of teamwork. Industry's ability to develop and utilize new technology depends a great deal on the use of teams at all levels to plan, design, test, manufacture, market, and maintain products. Rarely if ever does industry rely on one individual to work single-handedly to solve technical problems. Teamwork is recognized as being much more efficient because it uses the talents of several individuals to solve a single problem. The old adage of "two heads are better than one" is the basis for this concept.

Teamwork depends a great deal on the ability of individuals to cooperate with the other members of the group and to contribute their individual strengths to the benefit of the entire group. In sports this concept is what coaches rely on when they work to prepare a winning team. They try to direct individual strengths toward a group effort. This is precisely what industry attempts to do with many of its workers.

In this activity students will work in groups of four or five to solve a technical problem. Each team will be asked to design, test, and fabricate a device based on a common set of specifications. Follow the set of procedures as outlined below.

Procedure

1. The first step is to divide your class into groups of four or five students each.
2. Each group should be given a set of specifications for the problem to solved. The specifications will identify exactly what the problem is. For this activity the problem is to design, test, and fabricate an aluminum can crusher.
3. Next, study the specifications to find out exactly what the design criteria will be.
4. Once the group has studied and reviewed the specifications, it is important to set the goals for the group. This is the stage where individual responsibilities should be agreed upon and a schedule or timetable established.
5. The next step is designing the device. Your group should spend some time brainstorming ideas to come up with several possible solutions to the problem. Don't rule out anything in the beginning. Once you have developed several ideas your group should evaluate each one and talk about the positive and negative aspects of each.
6. After evaluating the designs, the group should select one good idea or combination of ideas that best suit the problem. From this idea it will be necessary to complete a set of working plans from which a prototype can be built. It is important to assign each member of the group some task. Some may be involved in the drawing of the plans while others can be looking for materials. If your group runs into difficulty at any stage, consult your instructor so that he or she can help point your group in the right direction.
7. After the prototype has been constructed it will be necessary for your group to evaluate its performance based on the design criteria established for the project. Pilot testing is important and a thorough testing should be completed before a final product is ready for production. It is important to check the prototype against the original specifications and insure that its performance standards and design are correct.
8. When your prototype has been tested, your group should prepare a presentation to the product selection committee. The purpose of this step is to sell the committee on your group's design.
9. The selection committee will evaluate each presentation and select the design which it feels best meets the criteria for a marketable product.
10. If time permits, your class can then market the winning design and turn the activity into a money-making project for the class.
11. Each group should write a technical paper summarizing its work. Describe all the steps it took to complete the project, from identifying the problem to evaluating the final product.

Evaluation

Evaluation of student performance will be based on participation in and completion of the activity. It is very important for students to understand the importance of their individual contributions to the overall effectiveness of the team. The instructor will discuss the overall project evaluations when the activity is completed.

Specifications

1. The device should be able to crush an aluminum can to a thickness of not more than 1 1/2".
2. The device should be designed such that the operator can easily crush a standard aluminum can with only one hand or foot.
3. The device should not weigh more than 8 pounds.
4. The device should be easily transportable and easy to operate and control.

DESIGN AND CONSTRUCT A HOME RECYCLING CENTER

Essential Elements: Common: 1-4, 6, 8-10
Specific: 2, 3, 10, 12, 13
TAAS Objectives: Math: C 4; O 1-4; PS 1-4

Activity Summary

This activity is intended to provide students with a group problem-solving project in which they design and construct a home recycling center. The activity follows the basic problem-solving process in which students begin with an established product description and specification list. Student groups will design a project, build a pilot model, and present the product to an evaluation committee.

Teaching Tips

1. Read through the entire activity and become familiar with the various sections before releasing to students.
2. Discuss the importance of recycling materials.
3. Discuss the problem-solving process.
4. Prepare a bulletinboard display illustrating the problem-solving process.
5. Review safety procedures for the various tools and machines which your students might use in completing this activity.

Instructional Strategy

- Lecture to present the topic to students.
- Use the problem-solving model.
- Use the teamwork approach for this activity.

Equipment/Supplies

1. Drawing paper and pencils
2. Drawing boards, T squares, triangles, and scales
3. Miscellaneous hand tools and machines as needed
4. Miscellaneous construction materials as needed
5. Finishing materials as needed

Evaluation Key

Evaluation of student performance will be based on participation in and completion of the activity.

DESIGN AND CONSTRUCT A HOME RECYCLING CENTER

Participate in a group project to design and build a household recycling center.

Objectives

- To use the problem-solving process in the design and construction of a product
- To have students work in a group activity in which they apply the principles of teamwork
- To develop personal skills associated with design and fabrication, from the design phase through finishing the project

Vocabulary/Concepts Reinforced

- Problem solving
- Teamwork

Equipment/Supplies

- Drawing paper and pencils
- Drafting equipment, including T squares, triangles, scales, drawing boards, etc.
- Necessary hand tools, machines, and equipment to construct student projects
- Necessary building materials

Introduction

The combination of teamwork and problem-solving is one of the most important instructional methods utilized in the Industrial Technology area. Not only is it important for students to learn the value of effective teamwork but it is important for them to understand and apply the problem-solving process. These two elements are lifetime skills which you will be able to apply in a variety of situations over the years.

In this activity we will add another important dimension, recycling. Recycling of materials is becoming a major concern to communities all across the country. This concern stems from a growing shortage of landfill areas and the decline of some raw material resources. Recycling will be one of the most important environmental issues facing technology in the 1990s.

In this activity students will work in groups to design and construct a home recycling center. This device should be considered a practical piece of furniture which serves to temporarily store materials to be recycled. It should be designed to be an attractive addition to the home, as well as a means of easy storage.

Read through the steps outlined below and proceed with the project.

Procedure

1. Divide your class into groups of three or four students. Each group will design and construct its home recycling device based on the criteria listed below.
2. The next step is to review the specifications for the recycling center. These are listed below.
3. After studying the specifications, begin your design sequence. Keep in mind that there are size limitations suggested for the device and that your group should try to keep within these limitations. Also remember that the recycling

center should be as easy to use as possible. You should design it so that people will want to use it.

4. After your group has developed several design possibilities, select one or a combination of several which you feel best meets the intention of the project.
5. Discuss the group design with your instructor. He or she may want to suggest alternate ideas for your design.
6. After your instructor has approved your project you may begin assembly of materials and production of a prototype. Make certain that each member of the group has a specific responsibility to perform. These should be clearly understood and it is the responsibility of each member to encourage other members of the group to take care of their individual tasks.
7. The completed prototype should be presented to the evaluation committee established by your instructor. This presentation should include a demonstration of the recycling center's effectiveness and efficiency.
8. The instructor will discuss and summarize each group's project. If time permits, the class may wish to choose one or more of the recycling centers to mass produce as a money-making activity.

Evaluation

Evaluation of student performance will be based on participation in and completion of the activity. Additional criteria may be used to meet individual situations as needed.

Design Criteria/Specifications

1. The home recycling center should be designed to store household recycling materials in small quantities for weekly disposal. It should be designed to provide separate storage for glass, plastic, aluminum, and newspaper. Storage containers may be 5-gallon plastic buckets or large grocery bags as available.
2. Size limitations should be about 36" high, 27" wide, and 16" deep.
3. Any construction materials can be used; however, the finished product should be attractive enough to sit inside a home.

PRODUCTION SYSTEMS
INSTRUCTOR'S RESOURCE SHEET 28
(3 WEEKS)

EXPLORE SPACE-BASED CONSTRUCTION

Essential Elements: Common: 1, 2, 6, 9, 10
Specific: 2, 6, 10, 12-14
TAAS Objectives: Math: C 1-4; O 1-4; PS 1
Reading: 1-6

Activity Summary

This activity is intended to provide students with a group problem-solving project in which they design and construct a model space station to service space shuttle orbiters. The activity will help students understand some of the basic problems associated with space construction and fabrication.

Teaching Tips

1. Read through the entire activity and become familiar with it before releasing to students.
2. Obtain as much material from NASA as needed to help illustrate some of the concepts associated with space-based construction and fabrication. Also check with your local school counselor for a list of resources available to students.
3. Obtain several models of the space shuttle for the various groups to use. They should be drawn to the same scale.

Instructional Strategy

- Lecture to present the topic to students.
- Use instructional media provided by NASA.
- Use the problem-solving technique.
- Use the teamwork approach to complete the activity.
- Use modeling to help present the topic to students.

Equipment/Supplies

1. Drawing paper and pencils
2. Drawing boards, T squares, triangles, and scales as needed
3. Space shuttle models
4. Miscellaneous materials to build simulated space structure
5. Reference materials as needed

Evaluation Key

Evaluation of student performance will be based on participation in and completion of the project.

EXPLORE SPACE-BASED CONSTRUCTION

Work in groups to design and construct a simulated space station to service space shuttle orbiters.

Objectives

- To help students understand some of the principles of space-based construction and fabrication
- To have students work in a group problem-solving activity in which they use modeling as a means of instruction

Vocabulary/Concepts Reinforced

- Airlock—A small chamber, located between the shuttle's mid-deck and cargo bay, which can be sealed off and slowly emptied of air until the pressure in the chamber is as low as that outside in space.
- Cargo bay—A large, open area of the space shuttle which is used to hold satellites and scientific equipment. It is covered by two large doors during takeoff and reentry. The doors can open during space orbit to access items stored in the bay.
- Flight deck—One of the two rooms inside the space shuttle. It is located above the mid-deck and contains the controls for the space shuttle, for the robot arm, and for most shuttle operations.
- Hatch —An airtight doorway in the space shuttle.
- Launch engines or main engines—Three powerful engines that burn liquid hydrogen and liquid oxygen to help lift the shuttle into space.
- Mid-deck—The larger of the two rooms inside the space shuttle where astronauts live during a flight. It contains the lockers that hold food and clothes, the kitchen area, and the space toilet.
- Mission Control—The room at Houston's Lyndon B. Johnson Space Center where NASA engineers monitor each space flight and issue instructions to the crew.
- NASA—An abbreviation for the National Aeronautics and Space Administration, the U.S. government agency that plans and operates space flights.
- Orbit—A path that an object follows around a planet or star, without having to use engines, because the force of gravity is pulling the object toward the planet's or star's surface. For example, Earth orbits the sun, and the space shuttle orbits the earth.
- Robot arm—A huge electrical crane shaped much like a human arm. It is operated by an astronaut inside the shuttle and used to place satellites into orbit or to pull satellites out of orbit. It can also be used to perform some space-based assembly procedures.

Equipment/Supplies

- Drawing paper and pencils
- Drawing boards, T squares, triangles, scales, etc.
- Space shuttle model
- Space station construction material
- Reference materials as needed

Introduction

Space exploration will continue to play an important role in the future of the United States. Much of the technology that we will use in the future will be the direct result of space-based exploration and development. The space shuttle is the first practical spacecraft which is capable of multiple trips into orbit. As its name implies, it has the ability to shuttle people and materials into space as needed and then return to earth.

One problem with space exploration is the refueling and servicing of space vehicles after they leave the earth. Space stations can be established in orbits outside the earth's atmosphere to serve as way stations for extended space travel. They can be manned with relief personnel, supplies, fuels, etc., for servicing space shuttles and other far-reaching spacecraft.

In this activity students will work in teams to design and construct a model space station that will provide service to space shuttle vehicles. The station should be designed to house personnel, relief crews, and stores for resupplying fuel, food, oxygen, water, etc. The space station should include some mechanism for docking and either unloading or taking on supplies. Imagine this station as a truck stop in outer space. A complete list of specifications will be listed in the procedure section of this activity.

The primary problem facing your design team is that all the materials for the space station must be launched into space via the space shuttle. The design can be modular to allow for final assembly in space, or it can be built entirely in space from materials transported via the shuttle. Your group may choose either of these methods or use a combination of the two for the design.

Procedure

1. Begin by reviewing the background material presented by your instructor. Become familiar with as much of this material as possible. If it is needed, your instructor may assign additional researching of background information.
2. Divide your class into groups of three to five students. Each group should meet to decide on a course of action and to assign individual duties. One or two members should begin building the model space shuttle at this time.
3. Study the specifications listed below and begin brainstorming ideas for your design.
4. Using the drawing equipment, design your space station and discuss the design with your instructor. Your instructor will provide specific information as to the amount of detail required at this stage. Use the completed model of the space shuttle to help design your space station.
5. When your design is complete, have your instructor check it against the project specifications.
6. With your instructor's approval secure the materials necessary to build the model of the space station.
7. Begin construction of the model space station. Remember that each member of the team should have some specific task to perform.
8. Upon completion of the station present your model to the class and be prepared to discuss the structure and how it will function. Use drawings and charts as needed to help in this presentation.

Evaluation

Evaluation of student performance will be based on participation in and completion of the project. Additional criteria may be established by your instructor as needed.

Specifications

1. The space station should be designed as a service station to replenish stores, fuel, oxygen, crews, etc., for extended space shuttle flights.
2. The space station will house a resident crew of four, with additional capacity for twelve transit crew members. The living area will include sleeping compartments; toilet facilities; storage lockers; a wardroom and galley furnished

with food processors and tables; a work compartment; an exercise room; a trash disposal device; a micrometeroid shield to protect the station; solar battery panels; and an airlock and docking system to access visiting shuttle vehicles.

3. A robotic arm may be used to help attach refueling lines and or other stores from the space station to the space shuttle.
4. The space station should be designed so that its component parts or modules can be transported into space via the shuttle and then assembled there. Another option would be to transport all of the parts into space and have the station constructed there by individuals working in spacesuits. Whatever option is selected, remember that all materials should be transported into space via the space shuttle vehicle. No more than five shuttle trips have been budgeted for transportation of construction materials. Your group needs to carefully consider this limitation. Your design needs to be compact in transit, yet large enough when assembled to house all the necessary components.

FOUNDATION STRUCTURES

Essential Elements: Common: 1, 7, 10
Specific: 2, 5, 6
TAAS Objectives: Math: C 4

Activity Summary

This activity is intended to provide students with a basic problem-solving activity in which they explore soil conditions and foundations as a structural form. Small groups of students will perform a series of experiments in which they test and compare various simulated soil conditions as well as the three basic types of foundation systems.

Teaching Tips

1. Read through the entire activity and become familiar with the various experiments before releasing to students.
2. Practice the experiments before demonstrating them to your students.
3. Prepare a bulletinboard display to help illustrate the problem-solving process.

Instructional Strategy

- Lecture to present the topic to students.
- Use the problem-solving model.
- Use the teamwork approach to this activity.
- Use the simulation method.

Equipment/Supplies

1. Several new sponges about 4" x 8"
2. Several old stiff sponges about the same size
3. Several 1/2" dowels cut to lengths as needed
4. Several pieces of 1/2" plywood cut into 4" x 6" rectangles
5. Several trays filled with sand (old darkroom processing trays work well)
6. Several pieces of 22-gauge galvanized sheet metal, about 18" long by as deep as the sand in the trays will be
7. Several beakers with water
8. Several bricks

Evaluation Key

Evaluation of student performance will be based on participation in class discussion and completion of the worksheets.

FOUNDATION STRUCTURES

Work in teams to experiment with soil conditions and various foundation systems.

Objectives

- To understand the basics of soil dynamics as they relate to foundation structures
- To develop an understanding of the main foundation systems used in general construction

Vocabulary/Concepts Reinforced

- Foundation—The portion of a building that provides structural strength to support the superstructure of the building.
- Soil—Usually refers to one of several types. Soils are classified by the general size of the particles of which they are composed. There are clay, sand, loam, gravel, and other classifications.
- Density—The number of particles per volume in various soils. Clay is a very dense soil; gravel is less dense. Generally, the denser the soil, the greater the stability it provides.
- Rock—There are four basic types of rock. It is the subsurface material that can support more weight than soil. Sedimentary rock, for example, can support as much as 40,000 psf, while stiff clay soil can support only about 4,000 psf.
- Settlement—When a structure is built on a soil base, it may very well settle as the weight of the structure compresses the soil. If the settlement is evenly distributed under the building, there is usually no adverse effect. If, however, the settlement is uneven, the foundation can fail, with cracks and other structural problems resulting.
- Spread foundation—This type of foundation spreads the weight of the foundation and structure over a large area by using a system of inner piers and an outer beam.
- Pile foundation—This type of foundation is used where the topsoil is very unstable. It incorporates a system of piles driven down into bedrock or firm subsoil. The structure is constructed on top of the piles.
- Slab-on-grade foundation—In warmer climates one of the most popular foundations is the monolithic slab. It is a one-piece slab, usually about 4 inches thick, supported by a series of deeper exterior and interior beams to help support the weight of the structure built on top of it.
- Gravity—One of the primary forces acting upon both the superstructure and the foundation of a building.

Equipment/Supplies

- 1—new sponge
- 1—old dry stiff sponge
- 4—1/2" dowel pieces cut to depth of sand
- 1—piece of 1/2" plywood cut to 4" x 6"
- 1—tray filled with sand
- 1—piece of 22-gauge sheet metal about 18" long and as wide as the sand is deep in the tray. Bend into a 3 1/2" x 5 1/2" rectangle.
- 1—beaker with water
- 1—ruler

Introduction

In building construction one of the most important structural components is the foundation. A foundation provides support for the superstructure of the building by establishing a stable platform on which the building can rest. It works by transferring the weight of the superstructure into the supporting soil as evenly as possible. This even distribution of weight results in a stable combination of foundation and superstructure that will remain structurally sound for many years. Any deviation in the evenness of the foundation support may result in failure of the floors, walls, and ceilings that rest upon it.

The soil on which the foundation is to sit is an important consideration for the type of foundation used. If the foundation is constructed directly on bedrock, there is little chance of foundation failure. If, however, the foundation is constructed on one of the many different types of soils, care must be taken to avoid uneven settlement. Some settlement is expected and will occur naturally over time. The important consideration is to insure that the foundation provides enough structural strength to withstand this movement and prevent damage to the superstructure of the building.

There are three basic foundation systems with several variations under each classification. The first system used is in a class called *pile foundations* (fig. 1). Although they are not used extensively in residential construction, pile foundations can be found along coastal or low-lying wetlands where other foundation systems are not practical. Pile foundations are primarily used in high-rise construction where an extreme amount of weight is to be concentrated over a relatively small area. Here, piles are driven down into either bedrock or extremely dense soil to carry the weight of the superstructure.

The second type of foundation system is the *spread foundation* (fig. 2). With this type of foundation the weight of the superstructure is spread evenly into the support soil through a system of foundation walls and columns, or piers and perimeter beams. The *wall system* is typical of homes built with basements. In this case the weight of the house is spread evenly downward through a system of columns and walls onto the supporting soil. Another type of spread foundation is the *pier and beam system*. With this type of foundation the weight of the building is spread evenly downward using a system of exterior beams and interior piers. This type is used where the grade changes are extreme.

The third type of foundation system is the *slab-on-grade system* (fig. 3). With this type the superstructure rests on a monolithic slab of concrete that is usually four inches thick, with a series of deeper beam sections that penetrate into the support soil to provide structural strength to the slab. One critical element of the slab foundation is the use of reinforcing steel placed both in the beams and throughout the slab. This steel provides the strength needed to keep the slab together. Another important element is the use of compacted fill material under the slab. This helps to stabilize the supporting soil and also works to prevent some moisture from penetrating through the underside of the slab.

Procedure
Complete the following set of student worksheets.

Evaluation
Evaluation of student performance will be based on participation in class discussion and completion of the worksheets.

Student Worksheet No. 1—Soil Conditions

Materials Needed:

- 1—new dry sponge
- 1—old dry stiff sponge
- 1—tray with dry sand
- 1—tray with damp sand
- 1—piece of 3/4" plywood 4" x 6"
- 1—beaker of water
- 1—ruler
- 1—brick

1. Place the brick vertically on the new dry sponge (fig. 4).
   Does the brick appear to be steady and secure? ____________________
   Why? ____
   Approximately how far has the brick settled into the sponge? __________

2. Place the brick vertically on the old stiff sponge.
   Does the brick appear to be steady and secure? ____________________
   Why? ____
   Approximately how far has the brick settled into the sponge? __________

3. With the brick standing on the old dry sponge, slowly add water around the base of the brick.
   What effect does the dry sponge have on the added water? ____________
   ____
   What effect does the moisture have on the sponge? ______________
   ____
   What effect does the moisture have on the stability of the brick?
   ____

4. Stand the brick vertically on the dry sand (fig. 5).
   Does the brick appear to be steady and secure? ____________________
   Why? ____
   Approximately how far has the brick settled into the sand?
   __________ ______________________________

5. Place the brick vertically on the damp sand.
   Does the brick appear to be steady and secure? ____________________
   Why? ____
   Approximately how far has the brick settled into the sand?
   ____

6. Place the brick vertically on the plywood (fig. 6).
   Does the brick appear to be steady and secure? ____________________
   Why? ____
   Approximately how far has the brick settled into the plywood?
   ____

7. According to your observations during the above testing procedures, which soil condition best represents solid bedrock? ____________________

8. Which of the above conditions represents expansive soil?
____

9. Which condition best represents the least dense soil condition?
____

10. Which condition best represents the densest soil condition?
____

11. Which soil condition resulted in the greatest amount of structural settlement?
____

12. Which soil condition would be the best overall for supporting a structure?
____________________ Why? ____________________
____

Student Worksheet No. 2—Foundation Systems

Materials Needed:

- 1—brick
- 1—tray with 2 - 3 inches of dry sand
- 1—piece of 1/2" plywood 4" x 6"
- 4—pieces of 1/2" dowel cut to depth of sand
- 1—piece of 22-gauge sheet metal 18" x depth of sand shaped into a 3 1/2" x 5 1/2" rectangle (see illustration)

1. Place the plywood on the sand, then place the brick vertically on the plywood (fig. 7). Observe the stability of the brick. Does it appear to be stable or unstable?
   Why?

2. Now place the four pieces of dowel into the sand under each corner of the plywood (fig. 8). Each dowel should be cut to exactly the same thickness as the depth of the sand and driven down to the bottom of the tray. Place the brick gently on the plywood. Observe any change in the stability of the brick. Does the stability of the brick improve or become less stable?
   Explain what happens.

3. Now place the sheet metal under the plywood (fig. 9). Remember that the height of the sheet metal should be the same as the depth of the sand. Press the sheet metal down through the sand onto the bottom of the tray. Remove the sand from inside the rectangular shape. How has this foundation system affected the stability of the structure?

   With the sand removed from inside the foundation walls, what additional forces are applied to the foundation?

4. Now add a little moisture to the sand and firmly press the plywood into the sand. Try to compress the sand directly below the plywood as much as possible. Push the plywood into the sand keeping it as level as possible and place the brick on top. Observe the stability of the brick. How does the stability of the brick on the plywood compare with that of the other two types of foundation structures?

   Why is it necessary to compact the material directly under the slab?

5. What type of foundation system is simulated by the dowels?

6. What type of foundation system is simulated by the sheet metal?

7. What type of foundation system is simulated by the plywood and compacted sand? ______________________________

8. What type of foundation systems are commonly used for residential construction in your local area?
____

PILE FOUNDATIONS

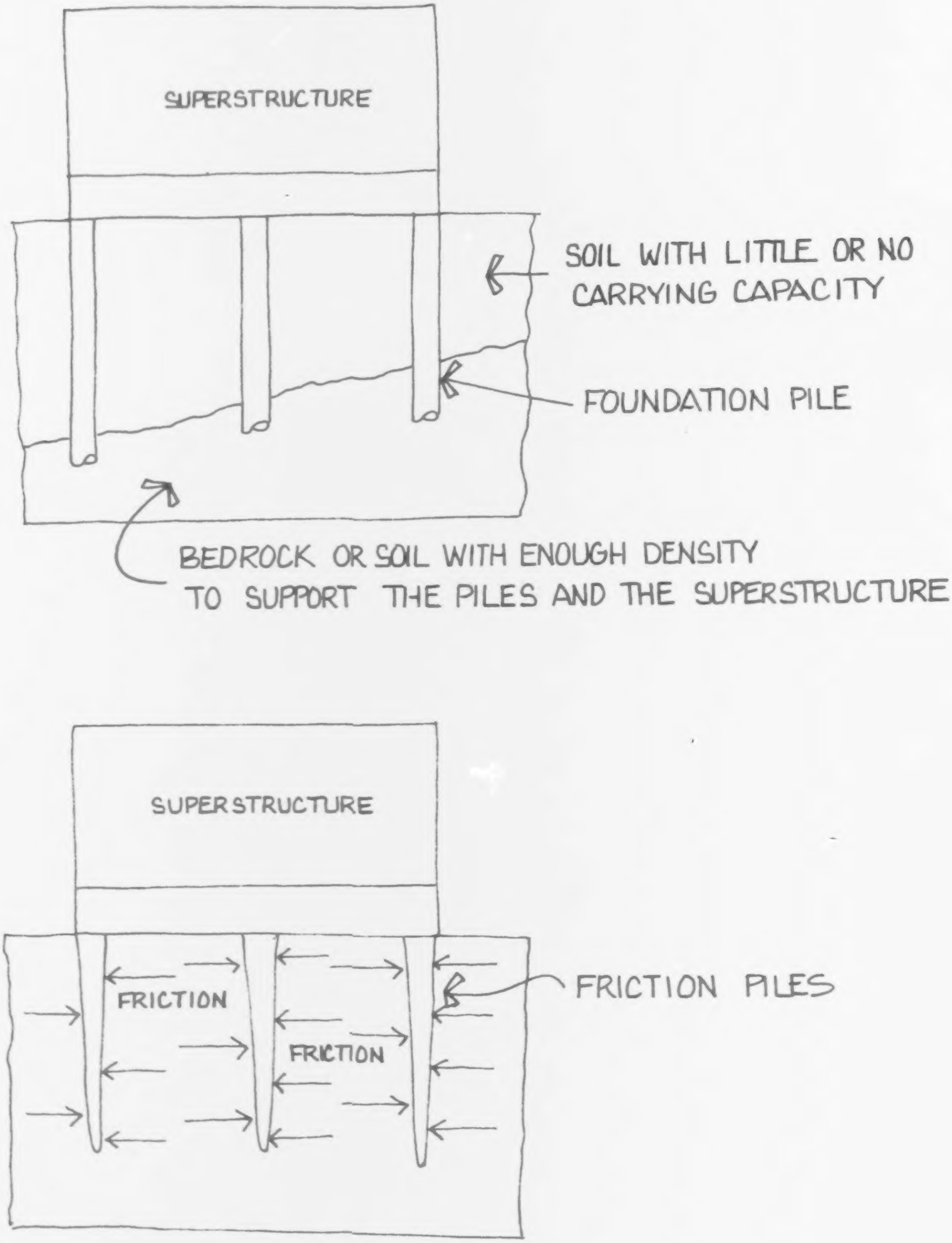

SUPERSTRUCTURE
SOIL WITH LITTLE OR NO CARRYING CAPACITY
FOUNDATION PILE
BEDROCK OR SOIL WITH ENOUGH DENSITY TO SUPPORT THE PILES AND THE SUPERSTRUCTURE
SUPERSTRUCTURE
FRICTION
FRICTION
FRICTION PILES

Figure 1

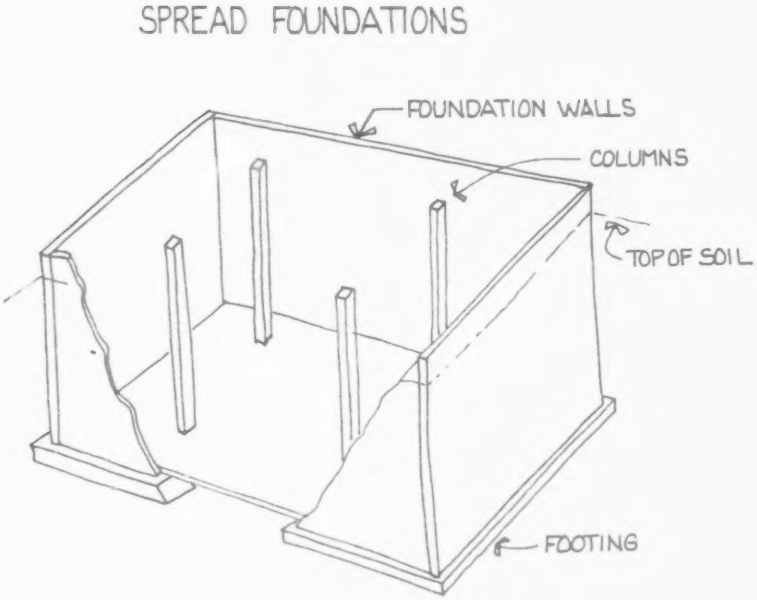

SPREAD FOUNDATIONS
FOUNDATION WALLS
COLUMNS
TOP OF SOIL
FOOTING

Figure 2

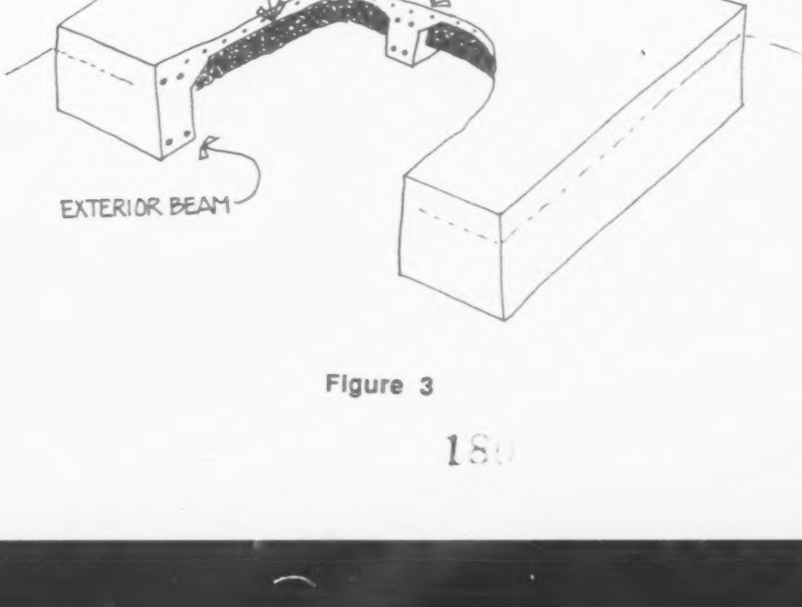

SLAB FOUNDATIONS
MONOLITHIC SLAB
COMPACTED FILL
INTERIOR BEAM
EXTERIOR BEAM

Figure 3

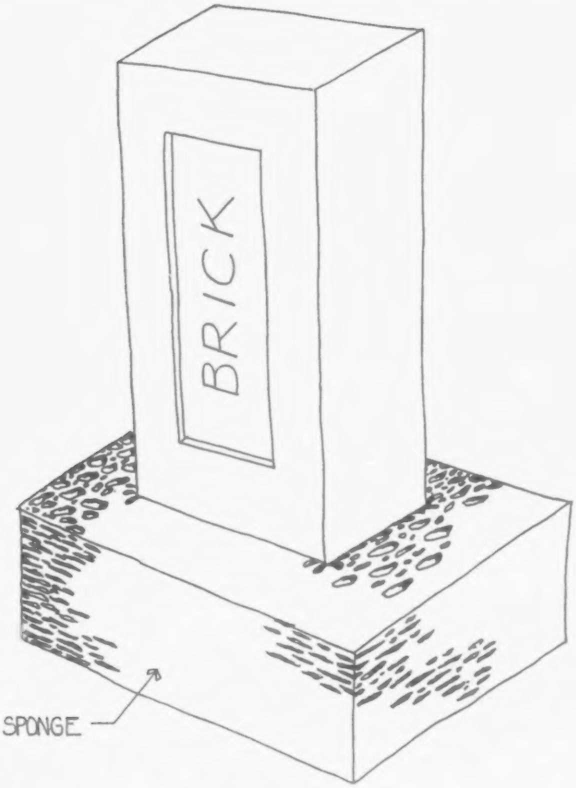

BRICK
SPONGE

Figure 4

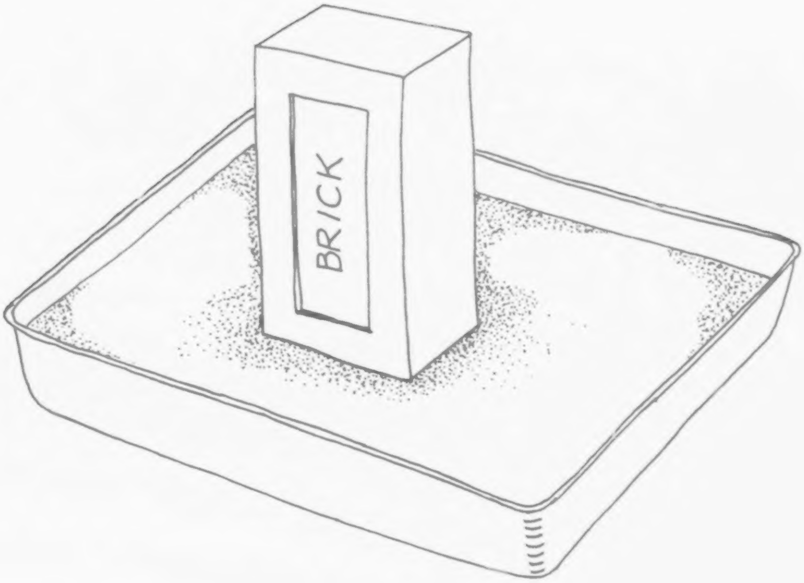


Figure 5

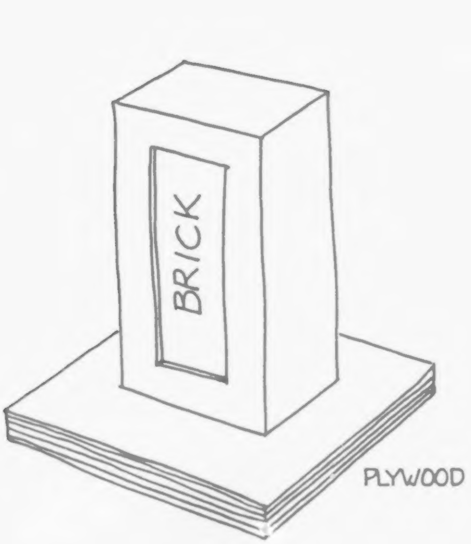

BRICK
PLYWOOD

Figure 6

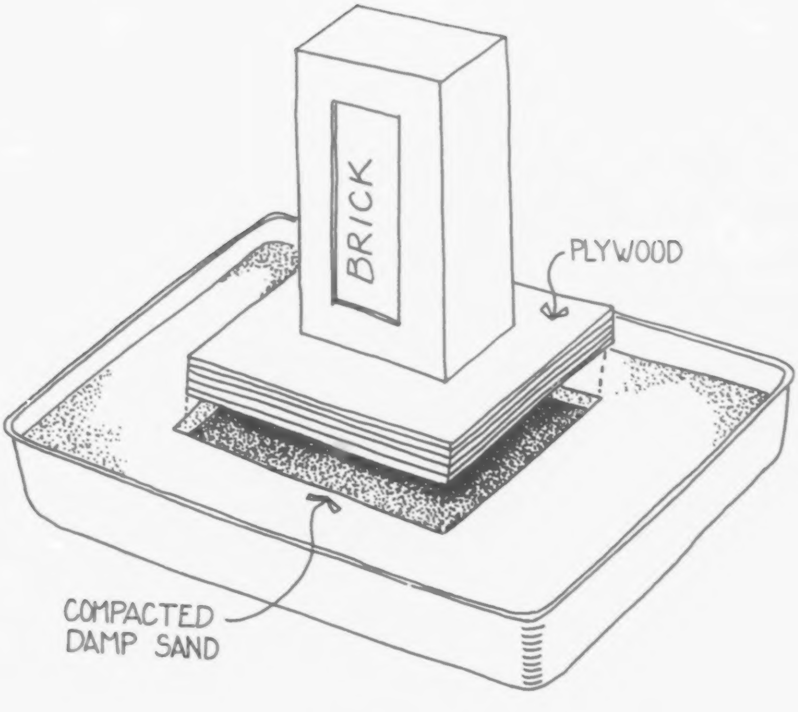

BRICK
PLYWOOD
COMPACTED
DAMP SAND

Figure 7

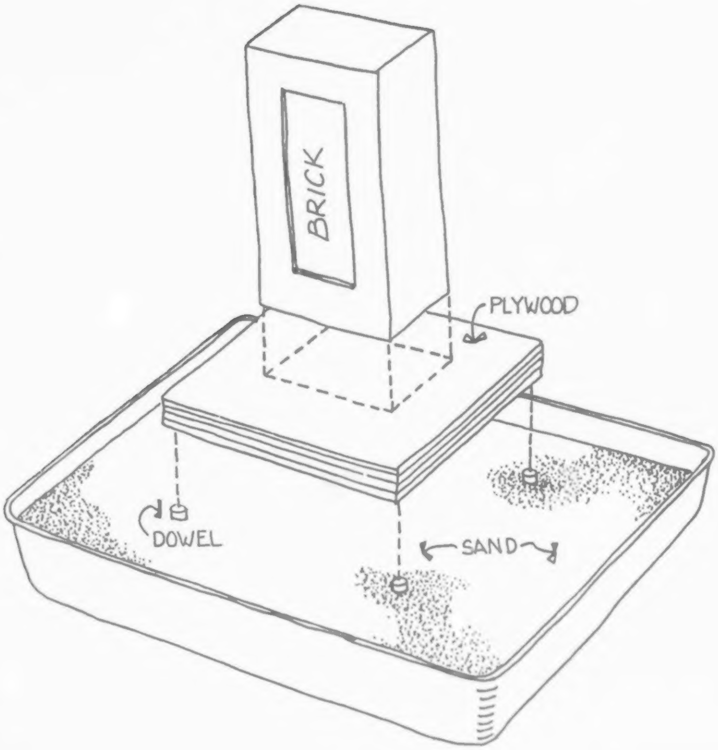

BRICK
PLYWOOD
DOWEL
SAND

Figure 8

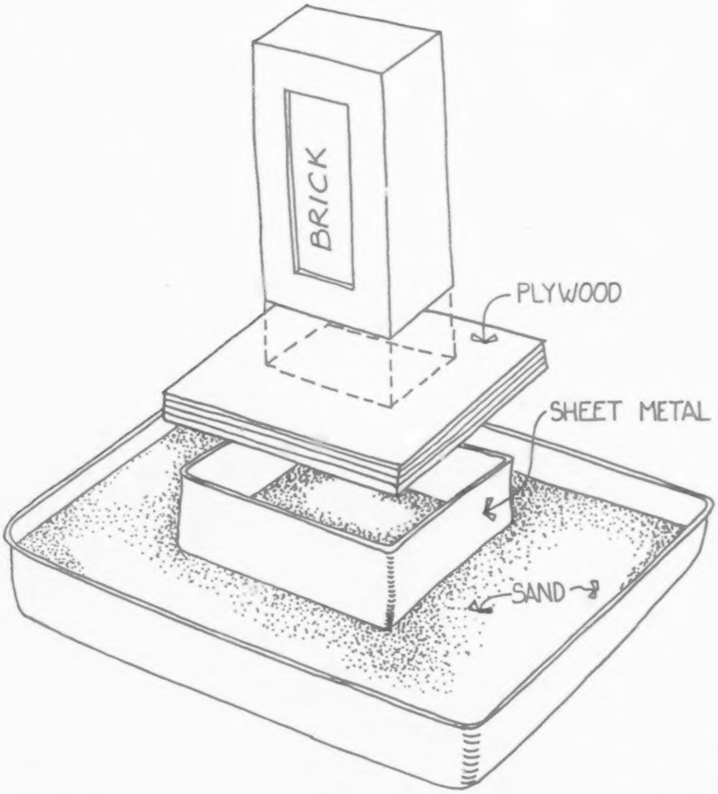

BRICK
PLYWOOD
SHEET METAL
SAND

Figure 9

STRUCTURES AND FORCES OF NATURE

Essential Elements: Common: 1, 2, 9, 10
Specific: 5, 6, 12
TAAS Objectives: Math: C 1-4
Reading: 1-6

Activity Summary

This activity is intended to provide students with a practical problem-solving activity in which they experiment with the various structural systems used in modern construction and the forces which act upon them. Students will complete a series of experiments in which they construct simulated structural sections and test them for the types of forces that act upon them.

Teaching Tips

1. Read through the entire activity before releasing to students.
2. Work through the various experiments before releasing to students.

Instructional Strategy

- Use the activity as either an individual or small group project.
- Use the elements of problem solving as needed.
- Use the simulation method to present the topic.

Equipment/Supplies

1. Several 4" x 6" index cards
2. Masking tape
3. Rulers

Evaluation

Evaluation of student performance will be based on participation in the activity and discussion and on completion of the worksheet.

STRUCTURES AND FORCES OF NATURE

Study the various effects of forces of nature on structures.

Objective

- To develop an understanding of the various forces acting upon different types of structures

Vocabulary/Concepts Reinforced

- Gravity—A force in nature which causes objects to be pulled downward giving the objects weight. In building construction gravity is what pulls a structure down toward the center of the earth. The effect of gravity is one of the most important considerations in designing and building a structure.
- Columns—A structural support system used in some types of construction to provide even distribution of weight downward to the foundation. Columns can be round or square, solid or hollow, tall and thin, or short and fat.
- Walls—Another type of structural support system used in building construction. Walls also provide protection from the outside elements. Walls are usually thought of as being the vertical members in a structure, but the roof might also be considered a type of wall system.
- Beams—Beams are used to provide additional structural strength by tieing either walls to other walls, walls to columns, or columns to other columns. Beams are usually found in either horizontal or inclined components.
- Compression—A structural force that presses or squeezes a structural member and causes it to contract or shorten. When force is applied to a beam, the top edge tends to compress.
- Tension—A structural force that causes a structural member to stretch or pull in a longitudinal direction. When force is applied to a horizontal beam, the bottom edge tends to want to stretch or pull downward away from its horizontal position.

Equipment/Supplies

- Several 4" x 6" index cards
- 1 roll masking tape
- 1 ruler

Introduction

Several forces act upon structures that stand above the ground. One of these forces, gravity, is an inherent characteristic that must be considered when designing and building any structure. Gravity is the force in nature which gives an object weight. All structures that stand above the ground and have weight also have a tendency to want to fall down. Compare your body to a building. Your body is capable of standing erect without too much trouble when you are standing on both feet. Try standing on one foot for a while and you become rather tired of keeping your balance. Try getting off both your feet for a couple of seconds and you'll find yourself falling to the ground rather quickly. (There are a few NBA players who seem to defy this force.) Gravity is one of the most dynamic forces that must be dealt with in any form of construction.

Procedure

In this activity we are going to explore a few of the basic characteristics that affect both the design and construction of structures. Complete the following student worksheets.

Evaluation

Evaluation will be based on participation in the activity and discussion and on completion of the worksheet.

Student Worksheet—Structures and Forces of Nature

Columns—Columns are one of the oldest structural forms and are common to much of the ancient architecture that is still standing today. Columns are used to support structural loads above the ground by evenly transferring the weight of both the structure and the columns into the supporting foundation. The general rule of thumb for determining the size of a column is that its height should be four times its diameter. The primary force working on the columns is gravity. In structural terms we classify the force as compression.

Using four of the 4" x 6" index cards, shape each into a column as shown in the attached drawings. You will need one for a tall round column, one for a short round column, one for a tall square column, and one for a short square column (figs. 1 and 2).

After constructing each column as shown, test each by gradually applying even pressure downward on its vertical axis.
Which column seemed to be the strongest? ______________________________
second strongest? ______________________________
third strongest? ______________________________
fourth strongest? ______________________________

What force is at work on the columns in this downward pressure?

____

What do you suppose is the primary contributing factor that makes the difference between the strongest and the weakest column design? ______________________________

____

Walls—The second structural form is the wall. A wall is usually a vertical member of a structure that provides strength while adding a protective covering for the inside of the structure. The strength of wall systems usually increases when they are tied together at intersecting corners. Generally, the higher the wall section, the stronger the lower section needs to be to support the additional weight bearing down upon it. Roofing systems can also be considered to be a type of wall. In construction a roof is sometimes referred to as the fifth wall.

Shape two of the 4" x 6" index cards into the corner section as shown in figure 3a. Press downward slightly on the outer walls. How do the walls react to this compression? ______________________________

____

Press downward slightly on the corner intersection of these two walls.
What observable difference occurs at the corner? ______________________________

____

Now, shape two additional 4" x 6" index cards into another set of walls and tape these to the first set (fig. 3b). This should form a complete wall system. Place a textbook on top of the structure and apply slight, even pressure until the walls begin to bend (fig. 4). At what point along the wall system does the wall begin to bend?

____

Why? ____

Now, place a fifth and sixth card inside the wall system as shown in figure 5. Again, place the textbook on top of the wall system and apply firm, even pressure. What notable difference occurs between this structure and the previous one?

____

____

Beams—The third structural system that we will experiment with is the beam. A beam is usually considered a horizontal or lateral structural member. Beams are often used to provide support for roofing systems or to tie wall sections together. Generally, beams are sized by the span which they are to cover, as well as by the weight of the load which they are to support. Two critical forces act upon beams. When a beam is put under stress, or a load is applied to it as it spans a distance between two walls, the top of the beam is under compression, while the bottom of the beam is under tension.

Fold one of the 4" x 6" index cards into the beam shape shown in figure 6. Place the beam so that it spans a distance between two textbooks while lying on its flat surfaces. Apply a gentle, even pressure downward on the center of the beam. What effect does this have on the shape of the beam?

____

What surface is in compression? ______________________________

What surface is in tension? ______________________________

Now, turn the beam so that it is standing on edge and press down slightly on the narrow top edge. What observable difference is there between this shape and the previous one? ______________________________

____

Which beam provides the greatest amount of structural strength?

____

COLUMNS

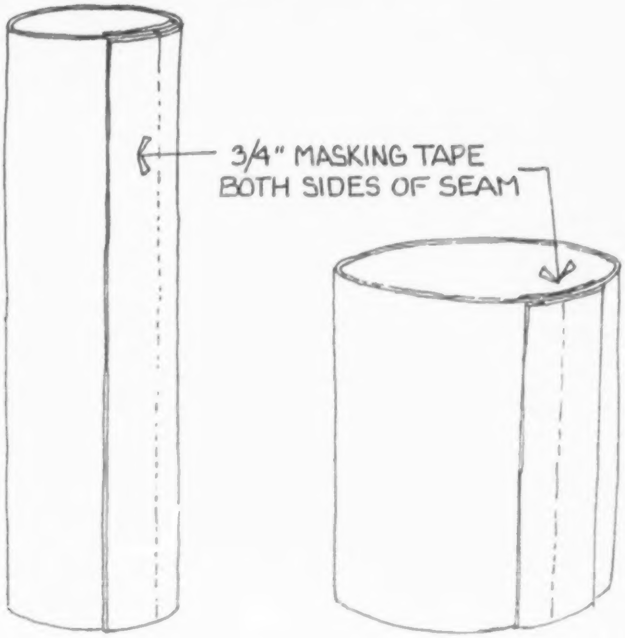

3/4" MASKING TAPE
BOTH SIDES OF SEAM

Figure 1

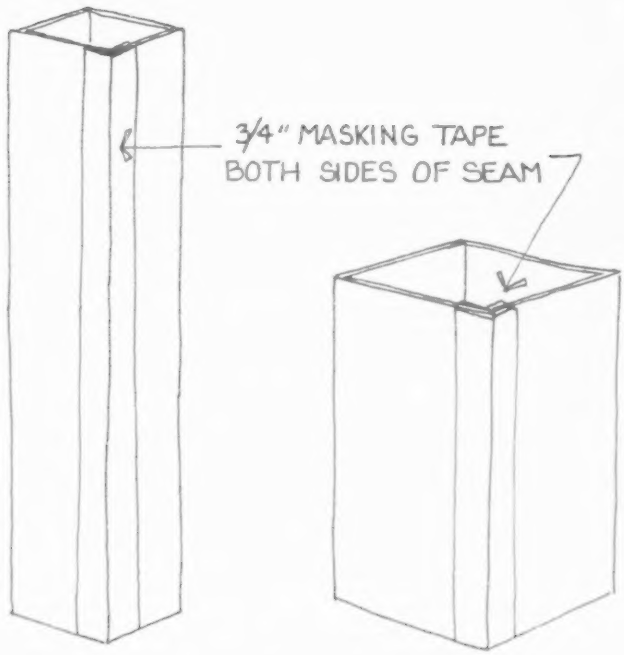
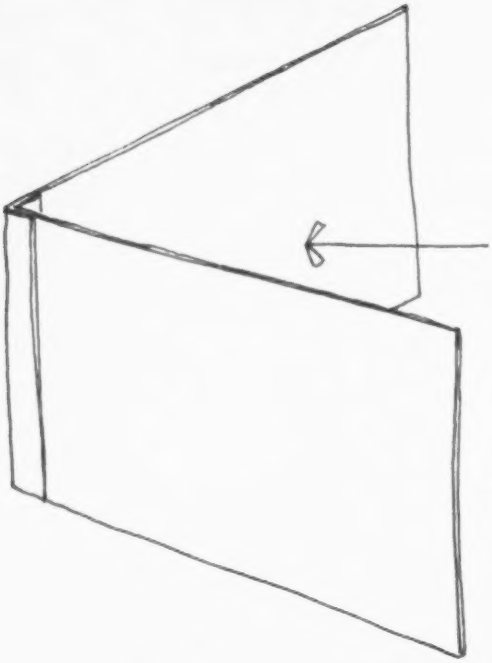

3/4" MASKING TAPE
BOTH SIDES OF SEAM

Figure 2

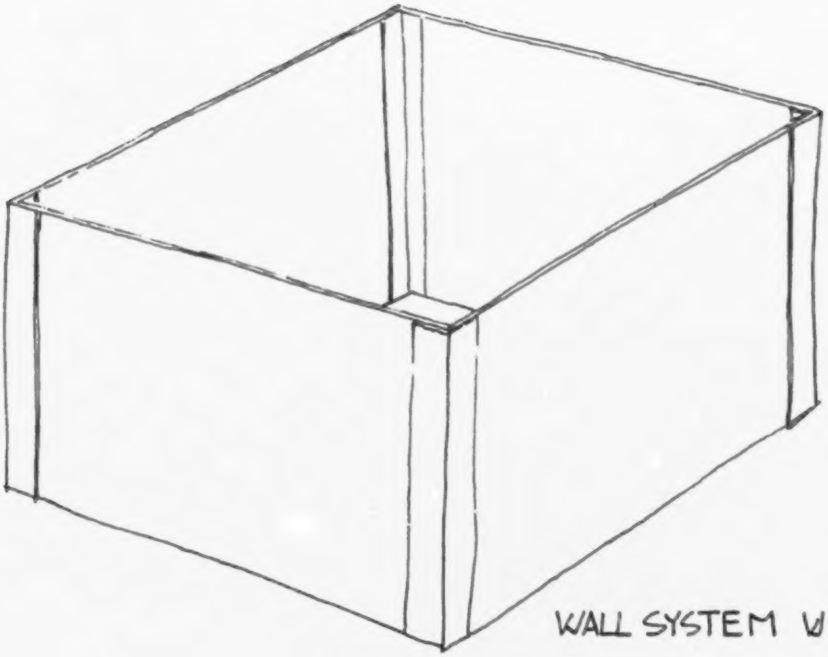
WALLS



3/4" MASKING TAPE
BOTH SIDES OF CORNER

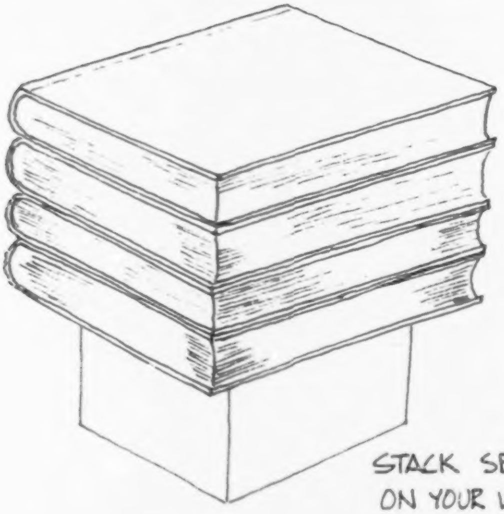
WALL SYSTEM WITH 2 WALLS

Figure 3a



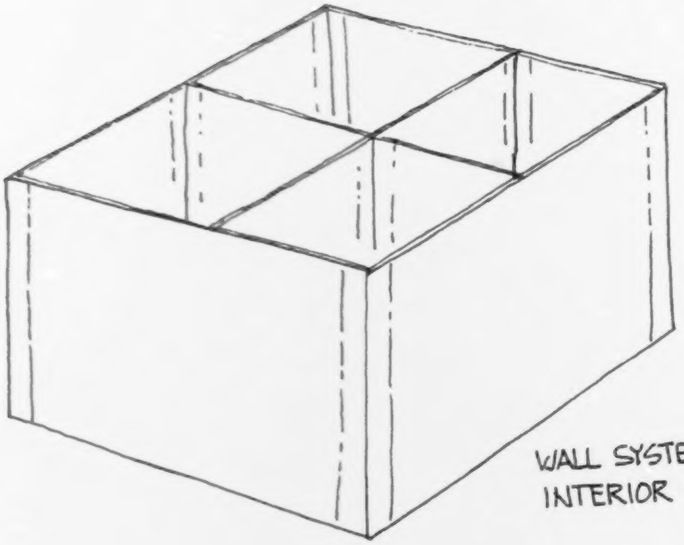
WALL SYSTEM WITH 4 WALLS

Figure 3b



STACK SEVERAL TEXT BOOKS ON YOUR WALL SYSTEM.

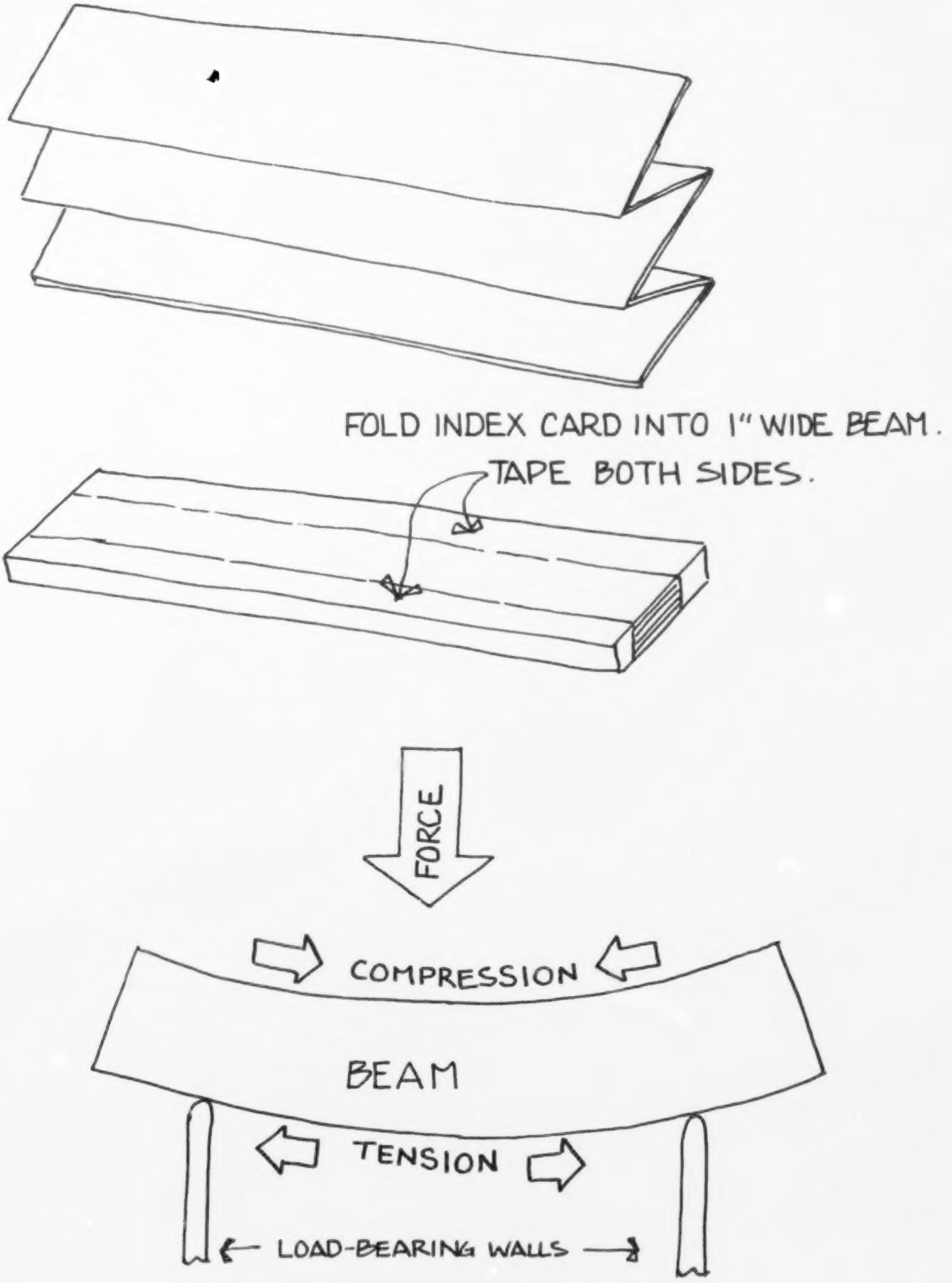
Figure 4



WALL SYSTEM WITH INTERIOR WALLS ADDED

Figure 5

BEAMS



FOLD INDEX CARD INTO 1" WIDE BEAM.

TAPE BOTH SIDES.

FORCE
COMPRESSION
BEAM
TENSION
LOAD-BEARING WALLS

Figure 6

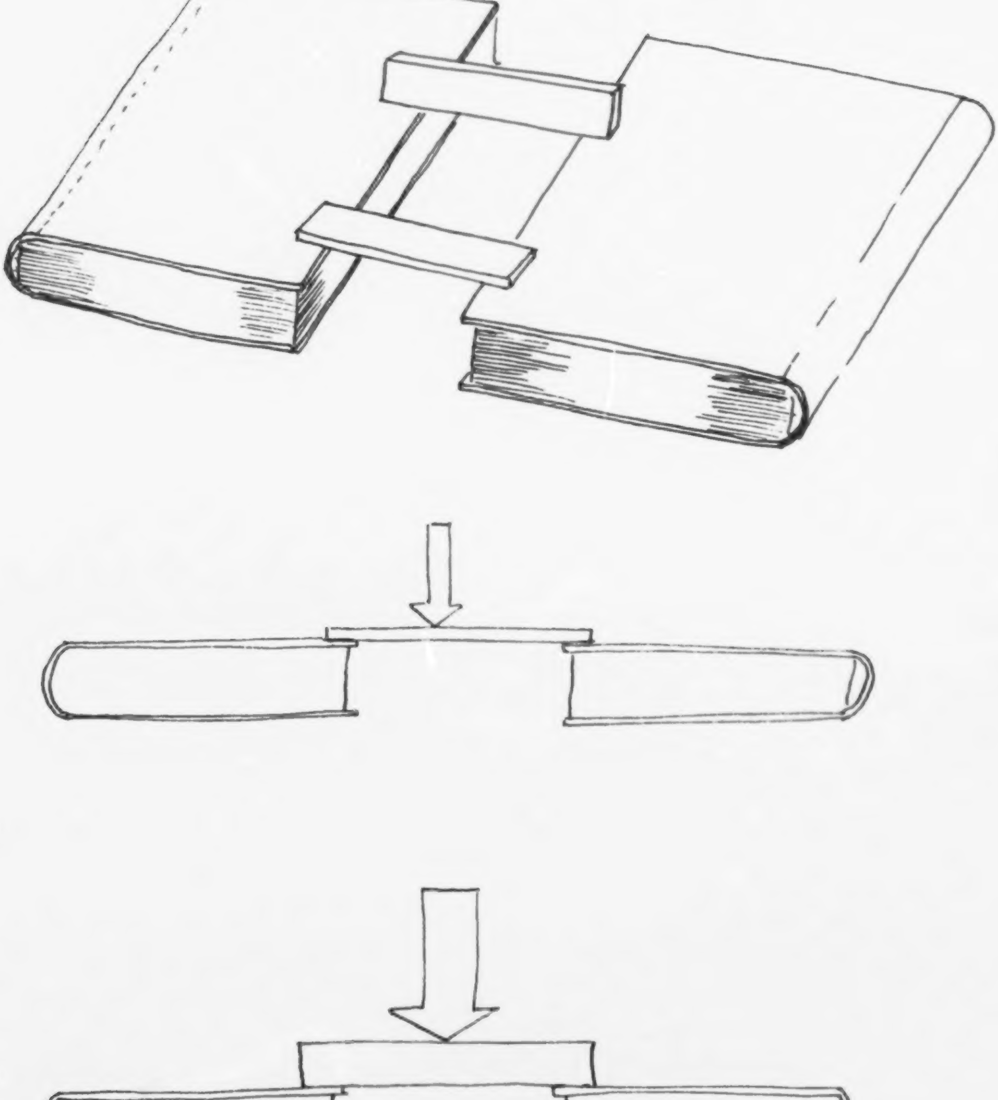


Figure 6 (cont.)

COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Office for Civil Rights, Department of Health, Education and Welfare.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964: EXECUTIVE ORDERS 11246 and 11375; TITLE IX 1973 EDUCATION AMENDMENTS: REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

It is the policy of the Texas Education Agency to comply fully with the nondiscrimination provisions of all federal and state laws and regulation by assuring that no person shall be excluded from consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any programs of activities which it operates on the grounds of race, religion, color, national origin, sex, handicap, age, or veteran status (except where age, sex, or handicap constitute a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency makes positive efforts to employ and advance in employment all protected groups.